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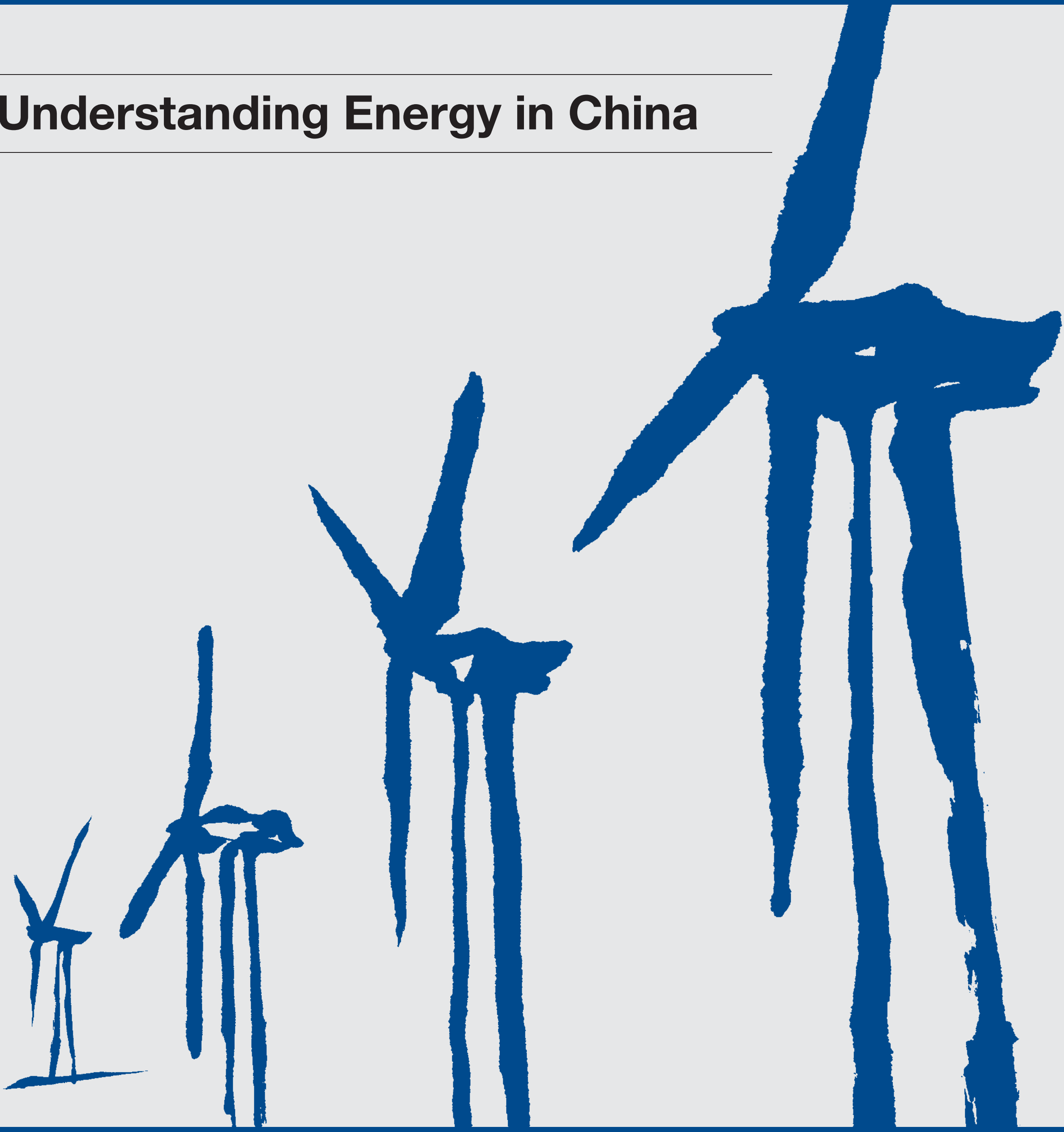
Understanding Energy in China



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FOREWORD

We are honoured to present here *Understanding energy in China*.

Our objective in this study has been to convey both the complexity and great progress made in Chinese energy development to a broad audience.

This work is published by the Asia Pacific Energy Research Centre as an independent study and does not necessarily reflect the views or policies of the APEC Energy Working Group, individual member economies, or other contributors. But we hope that it will serve as a useful basis for discussion and analysis both within and among APEC member economies for the enhancement of energy security, the promotion of regional cooperation, and in furthering sustainable development.

Kenji Kobayashi
President
Asia Pacific Energy Research Centre

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CONTENTS

SUMMARY

Understanding energy in China explores eight current topics in Chinese energy development in the context of reforms ongoing since about 1979.

ENERGY POLICY THROUGH THE REFORM PERIOD

China is a large and diverse economy and energy authority is diffuse. Rapid energy development through the reform period has therefore been somewhat *ad hoc* as central policy has had to compete with other forces to influence energy development. More generally, the limited reach of central governmental on overall energy development– not only in China but all throughout the APEC region– becomes more obvious as the pursuit of energy security underscores the global nature of the energy system.

This section, focusing on central government energy policy, offers a timeline which includes organisational changes, energy supply-oriented policies, energy-conservation-oriented policies, as well as energy pricing regimes, taxation, and government investment policies during the 1980s, 1990s, and 1990s. This is complimented by a detailed catalogue of energy development focus areas highlighted in the *Sixth* through *Eleventh 5-year plans*.

▪ Energy development policy outlined in 5-year plans has become increasingly comprehensive, detailed, and nuanced, but coordination among diffuse regulators and implementation on diverse actors hinders full realisation.

▪ Though prioritised alongside energy supply development through the reform period, energy efficiency policies have struggled to limit demand growth as intended given rapid economic development.

▪ Decentralisation of energy supply was necessary to sustain economic growth through the reform period but is now targeted for enhanced central oversight before further market-oriented reforms are implemented.

1.1 **Key points in "Energy policy through the reform period"**

ENERGY PRICING

Through the reform period, energy pricing has generally become more market-based. Measures taken to enable this shift have included reform of government price setting institutions, the introduction of a diverse set of investors into the energy market, and taxation reform. Importantly, the central government has expressed its intent to use energy pricing as the primary tool in achieving a market-based energy system. And though there have been great changes in the pricing of coal, electricity, oil and oil product, and natural gas, full pricing liberalisation will require policies and measures to address China's imbalance in energy resource type, affordability to end users, regional diversity, and coordination between central and local governments as well as enterprises and other energy consumers.

This section offers an overview of recent reforms, the current situation, and future trends of Chinese energy pricing, including coal, electricity, oil and oil products, and natural gas.

▪ Through the reform period, stronger price-adjustments have been implemented in periods when energy supply has lagged demand; price reforms in the coal sector have progressed more quickly than those for electricity, oil, and natural gas.

▪ Central government energy pricing policy seeks to reflect a wide range of economic, social, and political goals; local governments generally seek to boost local economic development as much as possible while implementing central government policies.

▪ Pricing reforms have dramatically affected real-world energy prices in China, gradually closing the international and domestic gap, but current energy price distortions reflect the incomplete nature of the pricing system.

2.1 **Key points in "Energy pricing"**

CHINA'S STORY OF COAL

Coal is both China's most abundant and most used energy resource, and it is therefore the most important fuel for China's energy security, economic prosperity, and future development. What happens in the story of coal affects all of China, and in an increasingly global economy, the world too.

This section examines coal demand and supply trends, current challenges facing the coal production industry including coal transport, and future options for continued coal development in China.

▪ Coal use has grown rapidly in recent years, driven by strong growth in electricity production and energy-intensive industries for which coal is a dominant fuel source and important feedstock.

▪ Coal production is increasingly concentrated in a few resource-rich provinces while consumption remains dispersed; to meet demand, some resource-poor but economically-developed areas are increasing coal imports from outside the province and even internationally.

▪ Rapid growth in coal use has stressed China's coal transportation infrastructure, creating supply bottlenecks, and domestic supplies remain tight as the coal sector faces central policy-driven resource consolidation, restructuring of small mines, and other new regulations.

2.2 **Key points in "China's story of coal"**

OVERSEAS UPSTREAM INVESTMENT AND PETROLEUM SUPPLY SECURITY

To fill the gap between a growing appetite for oil that exceeds production from domestic oil fields, Chinese state-oriented oil enterprises have increased efforts to acquire overseas upstream stakes of oil and natural gas. Supported by the central government through tax breaks and lower interest payments on overseas projects, China's three major state-oriented oil enterprises (CNPC, Sinopec, and CNOOC) are often considered to be global leaders in such investment efforts because of their visibility in a recent surge to acquire overseas upstream investment stakes and because of the sheer size of future Chinese petroleum demand. However, alarmist arguments about Chinese state-oriented oil enterprises are often exaggerated as they fail to put China's activities in the context of broader global trends.

This section explores the drivers of overseas upstream investment for Chinese enterprises, offers a brief history and current overview of such investment projects compared to similar undertakings by non-Chinese enterprises, and evaluates the relative impact of such investments on China's oil supply security through the development of unique APEC-region indicators.

▪ Contrary to common belief, Chinese state-oriented oil enterprises' involvement in overseas upstream project actually represents only a small share of global activity and has generally helped to increase global crude supply from baseline conditions through technology upgrade.

▪ Commercial motivations are high for Chinese state-oriented oil enterprises to be involved in overseas projects in order to compensate for weak profits in downstream and chemical segments.

▪ Indicator analysis suggests that China's oil supply security is relatively good. Into the future, however, China may need to bear extra costs in order to ensure stable oil supply from some politically turbulent regions in which it has invested.

3.1 **Key points in "Overseas upstream investment and petroleum supply security"**

ONGOING ISSUES IN POWER AND REFINING

A wealthier China's growing demand for more and higher quality energy alongside massive industrial investment is driving unprecedented investment in the transformation sector. Rapid growth, however, has come with challenges. The near-term measures taken by energy enterprises and government planners to address these will have long-term effects on structural reforms in the transformation sector.

This section has two parts. The first looks at the power sector, summarising recent reforms and market structure and exploring ongoing challenges including cyclical infrastructure investment, historical underinvestment in grid infrastructure, an overburdened coal delivery infrastructure, and an upstream-downstream price gap. The second part of the section looks at the refining sector in comparison to the power sector, again summarising the market structure, identifying similar pricing challenges, and comparing each sector's ability to respond.

- A vertically-integrated supply-chain structure makes refiners better able to respond to uneven or unsynchronised pricing reform in the transformation sector; power generators are now attempting to achieve similar cost-insulation.
- Current challenges in power and refining are driving consolidation, thereby enhancing central government oversight of these historically challenging to manage industries.
- China now faces a trade-off between the short-term desirability of such industry restructuring and long-term implications for market-oriented reform and liberalisation in these key energy sectors.

4.1 **Key points in "Ongoing issues in power and refining"**

ENERGY EFFICIENCY

Since the outset of the reform period, energy conservation has been prioritised as key to sustaining energy and economic development in China, encouraged by the central government through various policies, regulations, and measures. And though energy intensity continuously decreased until 2002, it has gradually risen since, becoming the target of ambitious government plans meant to extend its previous falling trend.

This section focuses on energy efficiency trends through the reform period as well as targets and programmes implemented to achieve efficiency improvement in those sectors with high potential, including energy-intensive industries, residential and commercial sectors, and power generation. It also includes a brief introduction to related aspects in the most recent *Eleventh 5-year guidelines*.

- Energy efficiency and intensity in the industrial sector has improved dramatically through the reform period—in some subsectors by as much as 10 percent annually—and potential for further improvement is still good as industry efficiency lags advanced international levels.
- Domestic power generation equipment manufacturers, having developed from technology importers to technology exporters and from joint-ventures to self-reliant design, manufacture, construction, and operation, now hold considerable potential to translate their own efficiency improvements into broader gains throughout the APEC region.
- As users have sometimes lacked favourable incentives to save energy, the central government has struggled to implement and enforce comprehensive and consistent energy efficiency policies during the reform period; efforts have therefore intensified in recent years to meet the ambitious targets of the *Eleventh 5-year guidelines*.

4.2 **Key points in "Energy efficiency"**

URBANISATION AND ENERGY USE

Urbanisation has been a visible and important trend in Chinese development during the reform period. And growth in Chinese residential energy use as a result of rising incomes and urbanisation is significant—even though this growth has been small compared to the even more dramatic growth in industrial energy use. Nevertheless, given the expansion in number and consumptive power of an urban middle class, the residential and commercial sectors can be expected to gradually change the character of Chinese energy use, manifested through demand in each household for convenient, high quality, and clean fuels. The timing and magnitude of these changes, however, will be unique to Chinese conditions and will depend on the economic, political, and lifestyle developments which are now taking shape.

This section examines ongoing patterns of Chinese urbanisation (including the economic drivers and demographic changes that result) as well as urbanisation's effect on residential energy use (including rural and urban consumption in the aggregate, geographic and demographic variation, and fuel switching over time).

- After declining through the reform period, urban household energy use has begun to rise rapidly in recent years with increased electricity and LPG use; direct residential energy use, however, is quite small in comparison to that of industry and continues to grows more slowly—it is not yet the main driver of energy demand growth in China.
- By encouraging the commercial and services sectors, Chinese urbanisation will be a key long term element in achieving the structural economic shifts that the central government has prescribed to achieve energy intensity targets.
- Lifestyle choice will be a key factor in determining the future character of urban development and energy use—residents in China's most developed cities are now setting expectations for middle to long term residential energy consumption growth throughout an urbanising China.

5.1 **Key points in "Urbanisation and energy use"**

CHINA'S AIR

Energy consumption is vital to China's industrialisation and economic progress. But energy consumption has environmental effects. A major concern in China is the emission of air pollutants from combustion of fossil fuels, especially coal. And though local pollutants are the most obvious today, China's environmental issues increasingly have regional and global dimensions. Although the challenges are great, China continues to make consequential progress on the environment both domestically and internationally.

This section examines historical trends of local air pollutants in China and progress in addressing them; a study of sulphur dioxide emission control in the thermal power industry exemplifies China's regulatory approach. From this perspective, the section suggests how past experience in dealing with local air pollution is now and will in the future be applied to technology development and application for global climate change.

- Pollution from energy activities, most importantly air pollution, remains a challenge in China; China is the largest emitter of sulphur dioxide and among the top in carbon emissions.
- Policy makers have implemented more stringent emission control measures and tackled more challenging pollutants over time, recently embarking on an ambitious plan to cut SO2 emissions and implement flue gas desulphurisation in new and existing thermal power plants.
- Success of SO2 emission control policies indicate the need for both affordable domestic technologies and political will in reducing pollution levels; China's approach will likely yield good results in reducing carbon emissions into the future.

6.1 Key points in "China's air"

CHINA ENERGY ISSUES

The following sections address various issues in Chinese energy development. Issue coverage is not meant to be comprehensive—rather, illuminating. As appropriate, each section is followed by a collection of related thematic maps showing economy level and regional historical trends in a particular energy indicator and accompanied by brief annotation. If the analytical narratives presented in each section fail to convey the continued achievement and complexity inherent to energy in China, the geographic data should speak for itself.

A few notes on conventions used in the text:

- "Energy" used here refers only to commercial energy and excludes the direct household combustion of biomass, unless qualified.
- "Provinces" used here refers to both true provinces such as Shandong or Yunnan as well as to other provincial-level entities including both autonomous regions such as Nei Menggu or Xinjiang and municipalities of China such as Beijing or Chongqing, unless qualified.
- Growth rates are given in "geometric" compound annualised averages rather than "arithmetic" averages, unless qualified.
- Currency values are nominal unless specified. "Real USD" refers to base year 2005 constant United States dollars and "real CNY" refers to base year 2005 China renminbi, without correcting for purchasing power parity, unless qualified. Currency values from 1986-2006 have been converted and adjusted using own-currency consumer price index values from the World Development Indicators published by World Bank. All other years follow conversions published by the Chinese National Bureau of Statistics.
- The multi-region energy and economic historical database used in this study has been developed based on publicly available statistics published annually by the National Bureau of Statistics of China and, in some case, other related energy industrial yearbooks. Statistical adjustments have been made as necessary, and energy conversions follow appropriate conventions. In some cases, data is not complete. For example, energy data for Xizang is not available and therefore not presented in the included thematic maps, whereas economic data for Xizang is presented as published. Energy data are likewise unavailable for Hainan before 1990, and for Chongqing before 1997.* Energy data for Sichuan before 1997 includes the current area of Chongqing.

INDUSTRY	SUBSECTORS
Primary	Farming, forestry, animal husbandry, fisheries and water conservancy
Secondary	Industry (mining and quarrying, manufacturing, electricity generation and supply, steam, hot water, gas) and construction
Tertiary	Transport, storage, post and telecommunications, wholesale, retail trade, catering, hotels, and other industries not listed elsewhere

7.1 **Chinese industrial categorisations for final energy consumption**

NBS and APERC 2008; "core industry" is used in the text to refer to manufacturing (heavy and light)

* *Hainan was formed as its own administrative unit in 1988 and Chongqing in 1997.*

Regions of China

- The six commonly-used regions depicted here are referred to throughout this publication for geographic reference. Despite this grouping, diversity is still broad within individual regions, and they carry no administrative significance beyond occasional statistical summary. Other informal region groupings are common as well, for example, "the northeast", "the west", or "coastal areas".

Energy Policy Through the Reform Period

Chinese energy policy trends are not obvious. China is a large and diverse economy and energy authority is diffuse. Considering this, it is not surprising that rapid energy development through the reform period has been somewhat *ad hoc*; central policy, even when clear and consistent, has not generally been the main driver of energy development. And the limited reach of central control on energy development— not only in China but all throughout the APEC region— is becoming ever more apparent as the pursuit of energy security underscores the global nature of the energy system.

China has witnessed a number of sometimes deft and othertimes unsuccessful attempts from the centre to influence energy development through the reform period. Major interventions are listed below, in sequence, and are categorised into one of four tool groups available to the centre to reach it's energy development goals:

Organisational changes

Reshuffling of central government ministries and specialised working groups reflects the need for officials to balance authority over time when interests are not aligned or when changing circumstances require it.

Energy supply-oriented policies

Since 1980, energy supply has been placed alongside energy conservation as central to energy development. Supply-oriented central policies have fluctuated between strong encouragement during times of shortage and restriction during locally-driven overheating.

Energy conservation-oriented policies

Officially given equal status alongside supply enhancement, conservation policies have helped China realise dramatic energy intensity and efficiency gains through the reform period. Central conservation policies though have sometimes struggled to keep pace alongside rapid investment-driven supply expansion in a growing economy.

Energy pricing regimes, industry and user taxes, and investment oversight

Gradual market liberalisation has been the centrepiece of Chinese reform, and has proven a potent tool for the central government in guiding energy development. The complexity of price control, however, has proven to be a challenging responsibility at times.

In addition to these tools, China's regularly-issued 5-year plans establish the overarching development frameworks for the entire economy, including the energy sector. Drafted by central government State Council bodies through a consultative process among provincial governments and leaders, these living documents provide macroeconomic guidance for further central and local policy development over their duration. 5-year plans are valuable in understanding energy developmental trends in China because they are the strongest, most unified voice of the Chinese government as a whole.

Below, these 5-year plans are described alongside other contemporary energy policy developments for the 1980s, 1990s, and 2000s.[a]

[a] *5-year plans over the reform period were generally composed of many complex targets, directives, and pieces of guidance and are distributed among government organs and across administrative levels. The descriptions given here draw heavily upon each plan's officially-released Chinese language summary, in-depth summary explanations, and other explanatory speeches generally delivered by the Chinese State Council Premier to the National People's Congress in the first year of each plan, as well as from official comments by other government advisors and think tanks, unless otherwise noted.*

SIXTH 5-YEAR PLAN (1981-1985)

"Energy shortage is a very important factor restricting our national economic development"

The *Sixth 5-year plan* called for primary energy production to expand by only 1.4 percent per year while industrial growth would grow by 4 percent per year over the same period. Therefore, energy conservation was emphasised so as to address this issue. Investment in energy conservation[b] doubled from (1980) CNY 1.486 bil in 1981 to CNY 2.987 bil in 1985 (768.5 million to 1544.7 million in real 2005 USD respectively), representing from 8.9 to 13.2 percent the total investment in energy supply over the period.[c] Overall, investment rose steeply during this plan period, and of the (1980) CNY 230 bil (118.9 billion real 2005 USD) centrally-planned investment envisioned for the period at the outset, 23.5 percent targeted the energy sector, with power drawing the most (CNY 20.7 bil, 20.7 billion real USD), followed by the coal (CNY 7.8 bil, 4.03 billion real USD) and oil (CNY 6.7, 3.46 billion real USD) sectors.[d]

[b] *Including non central government funds.*

[c] *Liu et al. 1994*

[d] *Hagemann 1983*

Conservation efforts focused on heavy and energy intensive industry, where production growth was envisioned to be driven by increased unit productivity per unit of energy rather than an increase in total energy consumption. Industrial sub-sector period targets for reduction of fuel use per physical unit output were: steel, 9.8 percent; power, 5.1 percent; ammonia in small factories, 12.3 percent; plateglass, 12.3 percent, and; crude "processing", 11.5 percent. Residential measures included popularizing the use of formed coal and upgrading cooking stoves as well as expanding the use of gaseous fuel and central heat for urban residents.

SUPPLY MEASURES

- For power (planned 3.8 percent annual growth in total production, same for hydro): increasing installed capacity; allocation of funds to convert oil-fired generation to coal-fired; improved generation efficiency in thermal and hydro; faster construction of quick-yield, cheap, large hydro; increased construction of mine-mouth thermal generation; improved management of power consumption.[e]

[e] *The plan includes only brief mention of power transmission, but acknowledgement of future continued attention because of uneven energy resource distribution.*

- For coal (planned 2.5 percent annual growth in production): expansion of capacity and labour productivity in existing mines through mechanisation; development of new mines in coal rich areas such as Shanxi to make up for coal shortage in central and southern areas.
- For petroleum (minimal production growth): maintaining existing levels of crude output; increasing natural gas output with

development priority on Sichuan province; cooperation with foreign partners for offshore exploitation; quality improvement in the refining sector, with special emphasis on increasing the yield of light product.

- For rural energy: distribution of efficient coal and biomass stoves to one-seventh of rural population; installation of biogas plants; planting of firewood forests; construction of small hydro generation and off-grid renewables.

Industrial growth targets were set according to physical production at 5 percent annually for primary and secondary industry. However, in reality, both showed significant gains over the period, exceeding 1985 target production levels by 1982. By 1983, despite rapid increases in coal production and electricity output, particularly hydropower, "production and distribution of energy remain[ed] a problem area"[f]. Over this period, China's dramatic fall in energy intensity began.

[f] *Hagemann 1983*

SEVENTH 5-YEAR PLAN (1986-1990)

In part reflecting energy supply and industrial production growth that was far faster than originally intended for the previous plan, the *Seventh 5-year plan* emphasised supply expansion to meet expected rapid demand growth. However, the central government also issued a number of new efficiency policies over this period, complimented by initiatives developed by local governments, intended to encourage new technology uptake by enterprise managers and limit energy consumption in industrial production, the most notable of which were the 1986 *Temporary provisions for energy conservation management*.

Though the share of investment in energy conservation to that of energy supply development gradually decreased over this period from 8.9 percent in 1986 to 6.4 percent in 1990, total conservation investment generally remained high, increasing to (1980) CNY 3.9 billion (2.017 billion real 2005 USD) by 1990.[g] Furthermore, the plan prioritised the energy sector of the economy to receive foreign investment and technology.

[g] *Liu et al. 1994; Sinton et al. (2005) offers an evaluation of conservation programs' effectiveness in the industrial sector through the Seventh 5-year plan, and concludes that a lack of funding for conservation investment hampered activities*

Regarding conservation, demonstration projects were highlighted as a means to propel the continued advancement of energy efficiency through technologic transformation, while the improvement of "economic efficiency" was proposed as a conservation measure. Other suggested measures included popularisation of effective energy efficient technology, equipment, and materials and a continued reduction of oil-fired combustion in general. Specific conservation measures described for the power sector included the broader use of prices as a lever to adjust power demand[h], the strengthening of power demand management, and improvements in grid dispatch.

[h] *For example, raising tariffs.*

SUPPLY MEASURES

- For power (planned 6.2 percent annual growth in total production): power was once again highlighted as the most important sector for energy development, with special encouragement given for localities to raise funds for power development; thermal power plants construction in coal producing and coastal regions, as well as other power demand centres; actively developing large and mid-sized hydropower stations; continued emphasis on development of nuclear power; strengthening investment in regional power grids.

- For coal (planned 3.3 percent annual growth in total production): production targets were set for each coal producing region; producers were directed to increase production with only modest investment; technological upgrades and extension of existing mine shafts; development of new shafts, with emphasis on small and medium sizes; encouragement for localities to raise funds for coal mine development; preferential assistance given to construction of selected medium- and small-sized local mines.
- For petroleum (planned 3.7 percent annual growth in crude oil production, 3.1 percent annual growth natural gas): progressively increase crude production; extend the production of ageing oil fields; introduction of foreign management experience and technology; strengthening exploration and development of natural gas, addressing the development gap between oil and gas.

Rural energy measures outlined in the plan were similar to those of the previous plan.

For the first time, GNP growth targets[i] were set, at 7.5 percent annually, somewhat of a compromise figure between the previous periods' growth targets and actual growth rates which far exceeded those targets, and with emphasis on rapid development of the tertiary industry. Geographically, the most advanced coastal manufacturing centres were given priority for further development, while central regions were highlighted for further energy and other resource extraction, with western regions largely put "on the backburner". Splitting the period into two phases, overall investment was to be frozen in the first "austerity" phase to stabilise an overheating economy so as to ensure fast growth through the second, post-1987 phase of the plan period.[j]

Taking economic and energy growth targets together, the plan called for an economy-wide energy intensity improvement of 12 percent[k]. The dramatic fall in energy intensity continued over this period.

[i] *Including tertiary industry and services.*

[j] *Hagemann 1986*

[k] *Measured with regard to income.*

13.1 Major developments in energy policy (1981-1990)

APERC 2008 and other sources [see References]

	ORGANISATION	SUPPLY	CONSERVATION	PRICING/ TAX/ INVESTMENT
1981	-State Energy Commission est.	-centre: supply and conservation given equal priority in development -Open Door Policy	-centre: supply and conservation given equal priority in development -central target: quadruple GNP per capita by 2000	-local governments tax quota system est., increasing local discretionary spending -contract responsibility system est. for oil producers, raising funds for exploration
1982	-CNOOC est.	-coal base development ann. for Shanxi Province		
1983	-Ministry of Water Resources and Electric Power est. -Ministry of Electric Power abl. -Ministry of Water Resources abl. -State Energy Commission abl. -Sinopec est.	-Daqing coal railway ann. -local and independent coal mines encouraged alongside state mines, stimulating production -small hydro pilot projects. ann for rural electrification		
1984				-local and private coal mines can sell at market price -some state coal mines can sell 5 percent of output at market price -taxes increased 25 percent for power industry
1985	-Huaneng est. from Coal-for-Oil substitution petroleum export fund	-centre: power sector given priority in energy development	-centre: incentives ann. to promote efficient tech at SOEs by allowing enterprises to chose production technology, raise depreciation rates, and transfer technology	-Temporary Regulation Regarding Incentives for Collected Funds in Electricity Development and Diversity for Price Setting est. to raise collective investment fund -local governments increase control over tax income -contract responsibility system for coal sector est.
1986		-Mineral Resources Law est.	-centre: temporary provisions for energy conservation ann., focus on management, investment, and reporting in industry -Mineral Resources Act est. to regulate fossil fuel use	-centre: tax deductions allowed for enterprises that invest in efficiency upgrades
1987		-20 Word Policy, separates business and government in power sector -local governments allowed to approve new energy infrastructure up to CNY 50 mil, thermal generation 800 MW, hydro generation 100 MW	-Provision for Further Strengthening Electricity Savings ann., sets limits for electricity use per unit production	-centre issues bonds and stocks to raise capital for utilities, CNY 3 bil (1.13 billion real 2005 USD) -contract responsibility system est. for natural gas producers, raising funds for exploration
1988	-Ministry of Energy est. -CNPC est. -Ministry of Water Resources and Electric Power abl. -Ministry of Coal Industry abl. -Ministry of Petroleum Industry abl. -Ministry of Nuclear Industry abl.			-State Energy Investment Corporation est. -tax of CNY 0.02 established for electricity users, to finance new medium and large generation -tax of CNY5 per tonne est. for oil producers -contract responsibility system for power prodcers est.
1989		-center: construction of thermal generation <10MW banned, but ineffective implementation	-Minimum Energy Performance Standards Program est., first appliance efficiency standards -Temporary Provisions Regarding Rational Utilization of Coal -centre: attempt to standardize efficiency reporting by sector	-Policies and Strategies in Energy Sectors outlines first long-term plans for pricing, taxation, finance, and trade
1990			-Temporary Provisions for Energy Conservation Monitoring	-state power generators can sell 10 percent of output out of plan

EIGHTH 5-YEAR PLAN (1991-1995)

Recognising that China's energy efficiency in industry remained poor despite rapid improvement in the previous decade, and that expansion of energy production would be difficult given geography and other constraints, the importance of energy conservation was once again highlighted in this plan to address chronic energy shortages in the face of rapid demand growth, exhorting to, "Continue to put expansion and conservation hand-in-hand, but give prominence to conservation." Total primary energy supply was targeted to grow at only 2.4 percent per year over the period while economic growth would be 6 percent per year, in the hope of "keeping demand and supply in balance." According to plan, this would have resulted in an economy-wide energy intensity reduction of approximately 9 percent over the plan period.

The share of total energy investment dedicated to energy conservation projects having gradually declined from its high of 13.2 percent in 1983 to 6.4 percent in 1990[l] as supply investment surged, a renewed conservation investment push over this plan period brought the share back up to nearly 9 percent in 1991, before continuing its gradual decline to just over 7 percent in 1995[m].

[l] *Liu et al 1994*

[m] *Jiang Lin 2005*

And though conservation was prominently described in the plan and related central government statements for this period, the plan itself nevertheless continued to focus more on "balanced and stable" supply expansion.

SUPPLY MEASURES

- For power (planned 5.6 percent annual growth in total production): further development of thermal and hydro power according to local conditions, as well as nuclear power where suitable; special attention given to hydro power development of all scales, particularly in areas with rich hydraulic resources; continued construction of thermal power generation at the mine-mouth, in coastal areas and along rivers, along railroads, and in high-demand centres; development of combined heat and power; major power generation construction projects are specifically named, including hydro stations in Sichuan, Guangxi, Yunnan, Hubei, Hunan, Xizang, and Qinghai, thermal stations in Nei Menggu, Liaoning, Shanghai, and Jiangsu, and expansion of the Qinshan nuclear station in Zhejiang; coordination of generation capacity addition with power grid development; strengthened development of rural power.
- For coal (planned 2.6 percent annual growth in total production): continued construction of the mine network alongside upgrade of local and township mines; construction of large-scale mines in Nei Menggu, Shanxi, and other regions in China's northeast, east, and centre, along with new open-pit projects in Shaanxi and Ningxia; continued technologic transformation and mechanisation of existing mines.
- For petroleum (planned 0.99 percent annual growth for crude, 5.6 percent annual growth for natural gas): stabilisation of the east

while developing the west; increase exploration and development in major existing fields to increase crude production in eastern regions; focusing western region exploration and development of oil and gas resources in the Tarim Basin, improving associated transportation infrastructure; undertaking exploration and development of coastal and marine oil and gas fields; giving priority to Sichuan for natural gas development, while strengthening production in existing gas basins.

In terms of regional economic development, coastal regions were directed to avoid development of energy intensive industries, rather, central regions with better energy resources were guided to lead energy industry development so as to alleviate shortages.

From a science and educational standpoint, resource identification research was to be directed toward gas deposits in the Tarim Basin as well as offshore petroleum deposits. Technology and skills development was also requested with regard to stabilising and raising production from existing eastern oil fields, coal production safety, clean coal combustion technology, hydropower development, construction of 200 megawatt nuclear reactors, energy saving technology, and new energy technology.

In order to accelerate energy production, the energy sector was directed to rationalise prices, raise funds for construction, attract foreign investment, and stably increase total capital investment.

The dramatic fall in China's energy intensity continued over this period, particularly in the industrial sector.

Unlike previous years, the plan also included a general outline of longer-term development through 2000, with broad targets for economic growth (6 percent annual growth, led by the industrial sector), electricity generation (5.9 percent), and coal production (2.6 percent annual growth); these extended targets were quite similar to those given for the shorter *Eighth 5-year plan* period itself.

NINTH 5-YEAR PLAN (1996-2000)

Under the banner of "Seizing the opportunity to deepen reform, broaden opening, and enhance development while preserving stability," and, "development of a socialist market economy," this plan focused on accelerated restructuring in the energy sector, namely the division of central government from business, as a means to increase high quality energy supply as necessary while improving the rationality of energy consumption. The annual economic growth target for the period was set at just over 8 percent.

At the outset of the plan period in 1996, total public investment in energy conservation in China dropped considerably for the first time since the beginning of reform, and did not recover to 1995 levels again until 2000. The share of total energy investment going toward conservation projects dropped from about 7 percent in 1995 to about 3 percent in 1996, recovering gradually to just over 4 percent by 2000. There are two likely explanations for this drop. One contributing factor was the dissolution of the State Planning and Development

Commission's (SPDC) China Energy Conservation Investment Corporation (CECIC), which had managed project approval for industrial energy efficiency low interest loans since the early 1980s when capital was less available for such projects.[n] This state-managed process was gradually abandoned over this period in favour of more market-driven finance mechanisms for energy conservation projects offered through commercial banks. Another related reason for the drop was an accounting issue, as firms increasingly leveraged private or other locally available financing to implement conservation upgrades instead of using central funds, or as once state-owned firms themselves became increasingly financially independent forcing or otherwise allowing them to use alternate forms of finance not included in the official statistics. Of course, in addition to the changing nature of the investment vehicles used, the decline may have also indicated a lapse in attention given to energy conservation by central policymakers over this period.

[n] *Jiang Lin 2005*

The plan began with an overview of growth during the previous plan period, though without explicit comparisons between reality and targets. Approximate annual growth rates were: for economic development, 12 percent (compared to 6 percent targeted); electricity production, 10 percent (5.6 percent targeted); coal production, 3.8 percent (2.6 percent targeted); crude oil, 1.5 percent (0.99 percent targeted), and; natural gas, 2.7 percent (5.6 percent targeted). Economic expansion far outpaced expectations and targets in the energy sector were handily exceeded, especially in electricity production, though with the noticeable exception of natural gas production.

Official explanatory documents[o] which accompany the plan summary offer a perspective on the major challenges facing the Chinese energy industry at the outset of the plan period in 1996. Noting that, "The energy industry is the most important precondition to support economic development," two major issues are explored:

[o] *Refer to 国民经济和社会发展"九五"计划和 2010 年远景目标纲:400 题解答. (Ninth 5-year plan with long range objectives to 2010 summary: 400 points)*

"Energy demand is not balanced by current energy supply"

According the explaining document, during the *Ninth 5-year plan* period, there was a need to improve supply of energy so as to meet demand, therefore making imports necessary to fulfil domestic production shortfalls. In particular, development of major state-oriented coal producers was deemed insufficient, suggesting that future production would primarily rely on township and village producers, who themselves nevertheless faced significant problems.

"The current energy structure is not rational and there is a serious shortage of high-quality energy"

The document noted that tight conditions in the supply of high quality energy such as petroleum, gas, and electricity had begun to limit economic development, observing that production of oil and gas had been sluggish, requiring imports, as has hydroelectric development, while nuclear power development had only just begun. Because of this, continued rapid economic development was though to require further dependence on coal, though this was acknowledged to have already brought problems such as stress on the environment and the transportation system.

CONSERVATION MEASURES

Primary energy production was set to grow at 1.7 percent annually, with energy conservation once again taking the fore—implementable energy conservation measures were more evident in this plan than those of previous periods. Directions outlined to achieve conservation and other gains included adjustment of energy supply and demand "structure"[p], the broadening of technology penetration, improving energy production efficiency, and consideration of environment alongside energy development in part through energy price adjustments.

[p] *Such as fuel switching.*

Other conservation measures outlined in the plan included strengthening energy efficiency legislation, enforcement, and monitoring, formulation of efficiency standards and regulations, and popularising the manufacture of non-energy intensive and efficient products while discouraging those that were not; the metallurgy, non-ferrous, chemical, construction material, and transportation industries in particular were targeted to undertake energy efficiency technology upgrades.

SUPPLY MEASURES

As in previous plans, power was described to rest at the "centre" of energy development, with coal "as its base" while simultaneously urging the continuing exploration and development of oil and gas resources and development of new energy sources. As in the conservation-oriented sections, this plan offered more specifics regarding supply development through the period than previous plans had.

- For power (7.0 percent annual growth in production, 16 megawatt annual[q] growth in generation capacity): continued placement of conservation alongside development, reliance on technological progress, and efficiency improvement in electricity consumption; continued structural adjustments such as the policies to separate government and business, establishment of provincial-level power entities, improving power grid connections, establishment of a unified power dispatcher, and collective fundraising in the power industry; as in previous plans, this plan called for further development of thermal and hydro power according to local conditions, as well as nuclear power where suitable, while specifying that power grid development should be carried out simultaneously with that of generation and accelerating the upgrade and construction of city and county-level power grids in particular; further development of mine-mouth power stations so as to displace the need for coal transport with power transmission; consideration of thermal power development alongside environmental protection, acceleration in the development of clean coal technology, and increasing the penetration of flue gas desulphurisation technology; research and development of long distance super high voltage power transmission technology to ease overall energy transportation, particularly with regard to the "West-to-East power transfer" project in hydro as well as mine-mouth thermal generation; for hydropower, step-by-step development of a cascading series of power systems in drainage

[q] *About 6.7 percent.*

areas, continued hydropower development at all scales, development of both low- and high-head power stations, all with respect to comprehensive resources utilisation among hydropower, irrigation, and waterborne navigation; continued development of new energy generation such as wind, tidal, and geothermal; strengthening structural adjustment in the power sector and restricting the development of small thermal power stations. The minimum single unit generation capacity for all new thermal power stations was set at 300 megawatts.

- For coal (1.5 percent annual production growth): "thorough" implementation of central and local enterprise consolidation plans, simultaneous development of large, middle, and small mines as necessary, continued adherence to the premise of rational development, stabilisation of production levels in eastern regions, accelerates development in Shanxi, Shaanxi, and Nei Menggu, and improvement in the labour productivity and efficiency of key mines; improving production efficiency for state-oriented coal mines in particular, overhauling management systems, and raising production levels and profit as allowed by technological progress; resource consolidation within established production regions, operation diversification, providing "support" to township and village-level local coal enterprises, and engaging in "orderly and healthy" development of railways.
- For petroleum (0.8 percent annual production growth for crude oil, 7.5 percent annual growth for natural gas): strengthening resource exploration so as to increase reserves and maintain a steady increase in production of oil and natural gas, in part through exploitation of foreign resources; on shore, focus on stabilising the east, developing the west, simultaneous development of oil and gas, and expanding openness; offshore, continued openness, expanded self-reliance, simultaneous development of oil and gas, and steadily raising production; upgrade and improvement of the existing oil and gas pipeline network while constructing new networks as well; strengthening [strategic] oil reserves.
- For rural energy: accelerating the adoption of commercial energies; popularising the use of fuelwood- and coal-saving household stoves; according to local conditions, vigorous development of small hydro, wind, solar, geothermal, and biomass energy.

The refining sector is also directly addressed, with a basic focus on improving the scale, quality, and light product yield.

The industrial development section begins with an admonition that, "The construction of infrastructure and other base industry should proceed according to an overall plan that rationally identifies main focus areas, with extra attention given to the guided development of "backbone" projects and the avoidance of blind or redundant construction." The energy sector in particular was directed to proceed with infrastructure development according the needs of broader economic growth, gradually easing existing bottlenecks.

For research, the plan described the importance of increasing scale in industry, such as the development of 700 megawatt hydro turbines, 60,000 tonne ethylene stoves, large ships, and large-scale cement manufacturing.

This plan also included a general outline of mid-term development, this time through 2010, though no numerical targets were given.

	ORGANISATION	SUPPLY	CONSERVATION	PRICING/ TAX/ INVESTMENT
1991			-Regulations for Energy Conservation in Coal Mines and Power Plants	-tax raised for crude producers
1992			-measures ann. to replace small power stations with larger ones	-price controls relaxed for coal production, stimulating production
1993	-Ministry of Energy abl. -Ministry of Power est. -Ministry of Coal Industry re-est. -local and independent power companies organised into 5 regional power groups	-Mine Safety Law est.		-price controls relaxed for crude production in some fields, improving finances -pricing policy for new power plants allow set return on capital investment
1994		-first nuclear power plant operational at Guangdong Daya Bay	-China's Agenda 21 est., outlines sustainable development plans	-National Tax System est., recentralises tax control but reduces incentives for conservation investment in industry
1995		-Law of Electricity, establishes legal basis for power reform and further separating business from government holdings -centre: limit development and operation of small thermal generators		-National Electricity Investment Company est.
1996	-National Mineral Resources Commission est.	-provinces begin to close small generators -Coal Industry Law est., enhances central control over production -Mineral Resources Law revised, enhances central control over extraction -Go Out program ann. to encourage oversees upstream oil investment	-Green Lights Program est.	-CECIC energy conservation investment vehicle abl., central conservation investment falls
1997	-Ministry of Power abl. -State Power Corporation est. -State Economic and Trade Commission assumes power policy		-Energy Conservation Law est., focusing on industrial sector, sets framework for future regulation; incorporated into provincial guidelines -Energy quotas removed for industry, intensity monitoring declines	-China Power Investment est. to raise and manage funds - Foreign Investment Industrial Guidance Catalogue ann. -natural gas prices revised upwards for most users, though fertilizer industry remains heavily subsidised
1998	-Ministry of Land and Natural Resources est. -State Administration of Coal Industry est. -Ministry of Coal Industry abl. -Sinopec and PetroChina asset swap	-centre begins to close small coal mines	-first stage of vehicle fuel efficiency standards est. [not effective until 2004] -Energy Conservation Voluntary Agreement est., pilot project for Shandong Province steel industry	-domestic oil prices set according to Singapore reference
1999	-China Coal Industry Association est. -SACI-controlled coal mines transferred to provincial level		-Outdated Technology Processes and Products catalogue aims to phase-out energy intensive equipment and processes in industry	-oil product fuel tax ann. by State Council but opposed by local government, not implemented -"illegal" electricity surcharges for end users abl., lowering prices, particularly in rural areas
2000			-updated Labelling Programmes and Energy Efficiency Standards for Household Electrical Appliances est.	-PetroChina listed in Hong Kong and New York, raising 2005 USD 3.29 bil -Sinopec listed in Hong Kong, New York, and London, raising 2005 USD 3.97 bil

20.1 **Major developments in energy policy (1991-2000)**

APERC 2008 and other sources [see References]

TENTH 5-YEAR PLAN (2001-2005)

This plan posited an annual growth rate of about 7 percent for the Chinese economy, alongside 4.5 percent annual declines in energy intensity. To achieve energy efficiency gains, secondary industry targets were set for steel production (0.8 tonnes), power (380 grams coal-equivalent per kilowatt-hour), non-ferrous (4.5 tonnes), ammonia, and cement/glass (20 percent reduction), alongside vehicle fuel efficiency (10-15 percent) and building efficiency improvement (50 percent energy use reduction). The share of conservation investment by the centre stood at about 5.5 percent in 2001, though this measure had gradually become less representative of total energy efficiency investment in the economy as the separation of government and enterprise progressed.

In terms of economic balance, this plan outlined reductions in the share of economic output attributed to primary industry (such as agriculture) and an increase in the share attributed to tertiary industry (such as services), with the share for secondary industry (including heavy industry) remaining constant over the plan's five year period. More broadly, the plan also sought to improve people's living standards and "build a well-off society."

Whereas the *Ninth 5-year plan* showed increased detail and ambition over previous plans in more specifically addressing energy sector developments, the *Tenth 5-year plan* instead took a broader perspective. Alongside ever-increasing complexity in Chinese energy development, this plan was in some senses more sophisticated than its predecessor, outlining the general direction and focus points on energy development and highlighting areas deserving increased attention while downplaying quantitative sectoral production targets in areas such as coal mining, for example.

Reflecting this new approach, the publicly-released descriptions of the *Tenth 5-year plan* included separate sections dedicated to topical issues such as energy and the environment which broadly outlined cross-cutting problems, reforms, and developmental aspirations in these areas. For example, an environmental module, "Development of the environmental protection industry" addressed prevention and control of air pollution (specifically flue gas desulphurisation and related pollution monitoring technology), water pollution, and solid waste (including the re-use of fly ash), as well as further development of water saving technologies (including in the power generation and petrochemical sectors).

Another module, "Energy conservation and comprehensive utilisation of resources" identified areas for further progress in energy conservation and energy efficient technologies. Reiterating the policy, first outlined two decades previous, to simultaneously develop energy supply and conservation, but to put conservation first, this module focused on encouraging rational resource use, "in accordance with the law." It is also significant in that it proposed that this be achieved by letting the central government step back, and "follow[ing] the guidance of the market, let enterprises be the main players".

CONSERVATION MEASURES

- For petroleum: petroleum conservation and substitution with alternative fuels based from coal, natural gas, methanol, and ethanol.
- For coal: use of clean coal technologies; development of large scale coal washing technologies, CTL, large-scale gasification, large-scale CFB, IGCC.
- For power: development of efficient motors, furnaces, transformers, transmission substations, ballasts, and domestic appliances, among other industrial applications; development of cogeneration, central heating, and CHP-cooling and CHP-gas.
- Buildings: development of weatherisation, insulation, climate control, and efficient lighting systems.
- Cross-cutting conservation policies: "Strengthen the building of the legal system and improve the implementation of policies"; "Formulate and implement energy efficiency standards and the certification and identification system, and standardise the market of energy-saving products" in industrial and residential applications, establishing an energy efficiency identification system according to the principle "voluntary first and compulsory second, pilot first and popularization second" in domestic appliances and later lighting and office settings; "Vigorously readjust the structure and promote the structural energy conservation and the optimization of the energy structure" through industrial restructuring, with emphasis on encouraging the services sector, increasing product added values, and faster technology turnover[r]; increasing the share of coal in power generation and share of power generation in total final energy consumption; "Promote technological advances and improve the overall technological level of energy conservation and resources comprehensive utilization"; "Study and formulate incentive policies that can satisfy the requirements of the market economy and promote energy conservation and resources comprehensive utilization" through energy prices and tax system reform, taxing inefficient energy-consuming equipment, and through preferential loans; "Explore the way to establish new mechanisms that can promote energy conservation and resources comprehensive utilization under the conditions of the market economy" through technology transfer, dissemination of best practices, development of ESCOs, comprehensive resource planning, government procurement policies, and voluntary agreements with enterprises; "Devote great effort to information services, publicity and training"; "energetically develop public transportation."

[r] *This emphasis on the tertiary sector did not fully align with industrial growth targets outlined elsewhere in the plan.*

SUPPLY MEASURES

- For power: development of hydro and large scale mine-mouth thermal generation, restriction of small thermal generation, moderate development of nuclear power, and development of new energy; reform of power management through gradual separation of generation and grid and, "bidding for power supply"; strengthening town and village power grids; construction of the south, central, and northern lines of the "West-to-East power transfer" project; increasing power grid interconnection in all areas; development of a number of specific hydropower projects; mine-mouth power plant construction in Shanxi, Shaanxi, Nei Menggu, Ningxia, Guizhou, Yunnan; further development of wind, solar, geothermal, and other new and renewable energies.

- For coal: improve productivity and efficiency of large mines.
- For petroleum: Oil was described as being of particular strategic importance in this plan, as China was facing an imbalance in supply and demand, stating, "We need to take all possible measures to conserve oil, accelerate exploration and exploitation of oil and natural gas resources, and make effective use of overseas resources."; increasing the share of natural gas production in relation to oil through preferential investment, financing, pricing, and tax; increasing the share of total petroleum production in relation to coal; development of oil and gas storage facilities; maintaining output from existing fields in the east through continued exploration and improved recovery ratios; increasing production in new western fields; accelerating oil exploration in the west, south, and offshore; improving pipeline and storage infrastructure, as well as LNG receiving terminals; overseas exploration in Russia, Kazakhstan, Turkmenistan, Iran, Iraq, Sudan, Venezuela, and Indonesia; development of public-private strategic oil storage capacity of 8 million cubic metres by 2005, to be managed by the central government so as to address supply and price fluctuations, to be implemented in parallel with an enterprise-based strategic reserve system; expansion of foreign joint exploration in onshore and offshore oil and gas; acceleration of coal gas development; increased enterprise freedom in oil and gas investment decisions, where the "government will assume the role of supervisor".

Other economic development directions described in the plan included:

- "Go Out" strategy[s]
- "Develop the West" policy: "Construction of infrastructure and protection of the ecological environment should take priority, and we should strive for major breakthroughs within five to ten years"; major infrastructure projects included the "West-to-East power transfer" project and the "West-to-East natural gas transfer" project; "The state will invest more in the west and increase transfer payments from the national budget to local budgets there."
- Central regions: "The central region should make use of its regional advantages and its comprehensive advantages of resources to accelerate its pace of economic growth."; "It should step up efforts to upgrade traditional industries with high, new and advanced technologies and raise its technological level and competitiveness."

[s] *Originally announced in 1996 for the petroleum sector, but reiterated and broadened here.*

- Coastal regions: "oriented towards both the domestic and international markets"; "improve general performance and competitiveness in the international market… areas where conditions permit should take the lead in modernisation."; "cooperation with the central and western regions."
- Industrial restructuring: "increase product variety, improve product quality, save on energy, reduce waste, prevent and control pollution, and increase productivity"; faster technology and other equipment development, both domestic and foreign; encouraging the growth of large, self-standing, competitive "pillar" enterprises through consolidation and stock listing; closing down old, inefficient, unprofitable, or otherwise poor-performing plants and mines.

ELEVENTH 5-YEAR GUIDELINES (2006-2010)

One overarching economic goal of the guidelines was a broad shift from an export-oriented economy to one supported by domestic demand. Guideline target indices were split into two categories: "anticipated" targets referring to those areas largely determined by market forces, such as economic growth, and "obligatory" targets supported by law, including energy conservation and environment protection. The guidelines outlined annual GDP growth of 7.5 percent, annual energy intensity reduction of about 4.4 percent (varying among provinces according to existing energy intensity performance and other economic and developmental conditions), annual total sulphur dioxide emission reduction of about 3.2 percent, and annual decrease of industrial water consumption per unit production of about 6.9 percent.

The ability of the central government to achieve plan targets under what had become a largely market-driven economy had became obvious over the course of the *Tenth 5-year plan*. GDP, trade, and tertiary industry all grew appreciably faster than outlined. The same was true of energy production and consumption, particularly coal production/consumption, oil consumption, and thermal and hydro power installed capacity and generation, which all far outpaced goals for the previous five year period. Targets were approximately fulfilled for domestic and overseas oil and natural gas production as well as thermal efficiency of coal power plants. Targets were missed, in some cases by a wide mark, for nuclear power installed capacity, the share of large scale power generation units, development of strategic oil stocks/ reserves, energy intensity, and air pollutant emission. For energy intensity, for example, the target reduction was 4.5 percent annually; instead there was a slight increase over the *Tenth 5-year plan* period.[t]

[t] *See Zhang Yue 2006 for a summary table of Tenth 5-year plan targets and results.*

Though previous 5-year plans had never stood alone in determining energy policy[u], the *Eleventh 5-year guidelines* were particularly notable both for their integration of existing contemporaneous energy policies, such as the 2004 *Medium- and long-term special plan for energy conservation*, and for the number of significant supporting or implementing policies which followed the guidelines' issuance, such as the 2006 *Top-1000 enterprise program* or the 2008 revisions of the *Energy conservation law*. Such integration changed the precedent for the position of 5-year plans

[u] *See accompanying chronological policy tables.*

or guidelines in relation to other elements of Chinese energy development.

The energy portion of the *Eleventh 5-year guidelines* were divided into a review of the current energy situation including important problems faced in energy development, overall directions and targets, infrastructure, conservation and environment, technology, and other overall policies. The overall philosophy of energy development remained similar to past plans, addressing the need to develop both energy supply and conservation but with an emphasis on conservation, as well as overall energy consumption diversification and "optimisation" of energy supply and demand structure.

Though coal was still described as China's energy "foundation", guideline targets indicated that its overall share of primary energy consumption should fall. Specifically, the plan outlines a decrease in the share of coal by 3.0 percentage points and that of oil by 0.5 percentage points over the five year period, and an increase the share of natural gas by 2.5 percentage points, hydropower by 0.6 percentage points, renewables by 0.3 percentage points, and nuclear power by 0.1 percentage points.

CONSERVATION MEASURES

Numerical targets were given for the physical efficiency of major industrial products and equipment, with the overall goal that by 2010, major industrial products reach "advanced international levels" of production efficiency of the year 2000, energy consuming equipment efficiency reach mid 1990s levels, and that automobiles and home appliances attain advanced international energy efficiency equivalency. Thermal power production was set to fall from 370 to 355 grams of coal-equivalent per kilowatt-hour from 2005 to 2010, "comprehensive" steel production from 760 to 730 kilograms coal-equivalent per tonne, cement from 159 to 148 kilograms coal equivalent per tonne, and rail transport from 9.65 to 9.4 tonnes of coal-equivalent per million tonne-kilometres. Coal-fired industrial boilers were set to improve from 65 percent to 70-80 percent efficiency between 2005 and 2010, small- and mid-sized motors from 87 to 90-92 percent, compressors from 75 to 80-84 percent efficiency, and automobiles from 10.5 to 12.2-14.9 kilometres per litre "fuel". Other energy industry-specific targets also included improving extraction efficiency and reducing water use in coal mines, as well as eliminating coal mine waste water discharge and increasing the percentage of washed coal. Thermal power plants were directed to reduce own-use of produced electricity from 5.9 to 4.5 percent, line-loss from 7.18 to 7.0 percent, and total sulphur dioxide emission by at least 10 percent.

- For coal: Continued closure of small inefficient coal mines (reducing from 22,000 in 2005 to about 10,000 small mines in 2010), retrofitting existing mines, construction of large modern mines, and increasing coal mine gas usage from 1 billion cubic metres to 8.7 billion cubic metres. Other measures aimed at improving the environmental performance of coal mines, in part through higher capital investment, and included reduction of soil erosion and increased land rehabilitation.

- For petroleum: Strengthening evaluation of efficiency and environmental performance in oil and gas fields by improving recovery ratios, implementing new extraction technologies, utilising associated gas, as well as reducing local pollution.[v] Continued substitution of fuel by coal, coke, and natural gas, improved fuel efficiency standards of automobiles, promotion of hybrid and other advanced "clean" automobiles, and natural gas use for urban buses and taxis.

[v] *As in the coal section, many of these "conservation" measures in fact seemed aimed at improving supply, and were previously listed as such in other 5-year plans.*

- For power: Developing the use of large ultra-supercritical generation units above 600 megawatts while closing small power plants; detailing plans for the use of heat, including combined heat and power of various scale (as well as CHP-gas and CHP-cooling) in industrial areas and more extensive district heating in urban areas. Installation of desulphurisation equipment at thermal power plants and reduction of particulate emissions and wastewater discharge (particularly in new plants), as well as trial implementation of nitrogen scrubbers. Improving electricity transmission, conversion, and distribution through adoption of new grid technologies and equipment and reduced line losses.

Supply measures

- Orderly development of coal, accelerated development of oil and natural gas, "positive" development of hydropower in consideration of environmental protection and resident relocation, "optimised" development of thermal power, promotion of nuclear power construction, and "energetic" development of renewable energy. Moderate acceleration of coal exploration and development in the "Sanxi" area[w], oil and natural gas in the central western regions and offshore, and hydropower in the southwest. Increasing the output capacity of energy bases; optimising the development of eastern region coal and petroleum resources, and stabilising production while easing energy transportation stress.

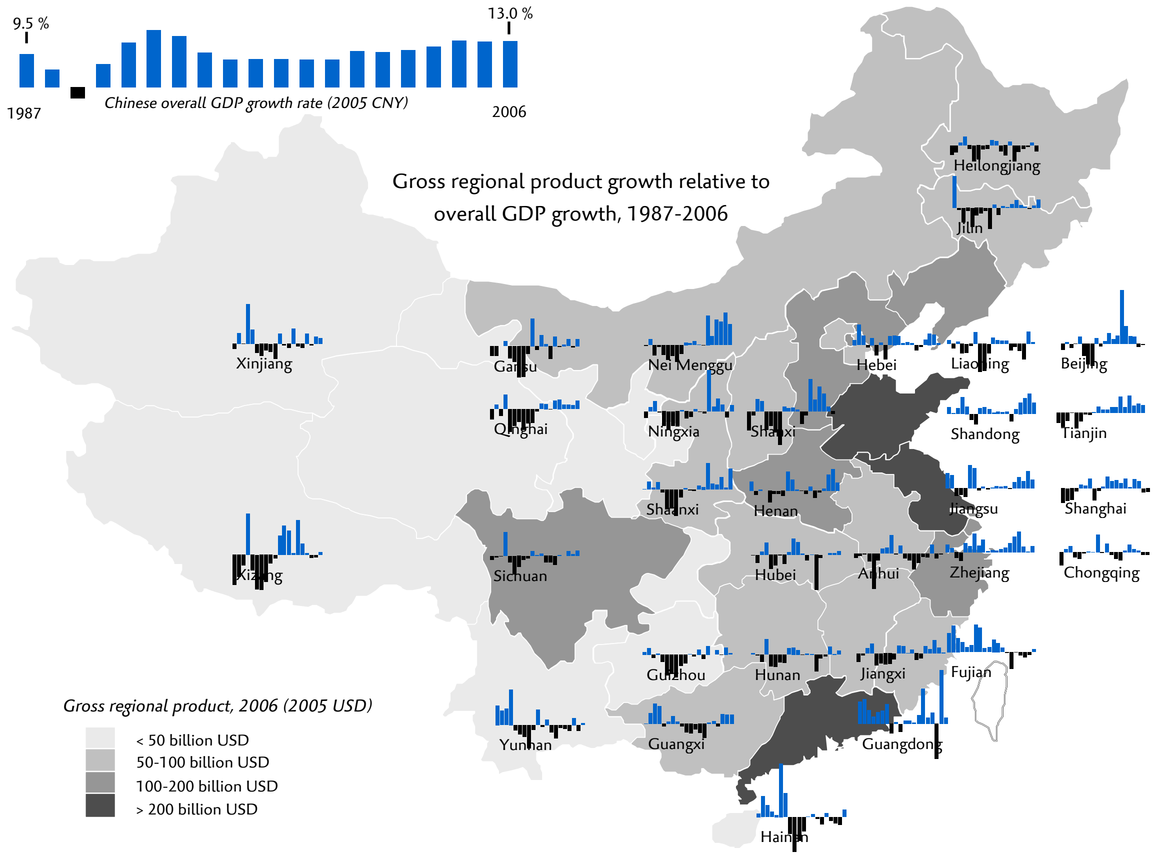
[w] *Shanxi, Shaanxi, and Nei Menggu.*

Special sections were included for the continued development of energy transportation systems, including coal transport rail lines and ports, oil and gas pipelines, and electric grid construction (including both long distance high voltage transportation as well as local grid interconnection). Renewables were once again highlighted as a good way to address rural energy development and identified as an area in which to improve technology and production capability, including for biomass electricity and biofuels.

	ORGANISATION	SUPPLY	CONSERVATION	PRICING/ TAX/ INVESTMENT
2001				-CNOOC listed in Hong Kong and New York, raising 2005 USD 1.38 bil
2002	-State Power Corporation abl. -5 state-oriented generators formed -State Grid Corporation and China Southern Power Grid est.		-central target: quadruple 2000 GDP by 2020	-new Foreign Investment Catalogue ann., following WTO entry, relaxes barriers encourages investment in coal mining, power generation >300MW, emphasises investment in central and western regions
2003	-National Development and Reform Commission est. -Energy Bureau est. under NDRC -Electric Power Regulatory Commission (SERC) est.	-pilot projects ann. to substitute rural thermal generation with small hydro		
2004		-West-East gas pipeline operational (Xinjiang-Shanghai) -National Oil Reserve Plan ann.	-first Medium- and Long-term Special Plan for Energy Conservation est., sets indicators, targets, and 10 key focus areas across sectors -Government Procurement Bill for Energy Conserving Products ann., includes catalogue -Circular on Organising Special Inspection and Resource Saving aims to improve compliance with efficiency standards	-Decision on Reform of Investment System decentralises enterprise investment while strengthening macro controls -new Foreign Investment Catalogue encourages E&M to improve extraction, natural gas generation, CFB manufacture
2005	-Energy Leading Group and State Energy Office est. to help coordinate energy policy direction	-National Comprehensive Energy Strategy released by SC-Dev. Research Centre, policy recommendations for energy dev through 2020 [not law] -Coal Industry Law revised, focuses on safety and standards	-Renewable Energy Development Law est. -centre: Promotion of Public Transport, encourages urban infrastructure development -centre: building efficiency guidelines ann.	-central government subsidises Sinopec for refining losses
2006		-Guangdong Dapeng LNG terminal operational -initial deliveries through first of three segments of Kazakhstan-China oil pipeline -centre: 3 Year Plan for Closing Small Coal Mines	-tax increase for large automobiles, tax reduction for small automobiles -Top 1000 Enterprise Program est, sets industrial efficiency targets for 2010 -Medium and Long-Term Technology Policy Plan est.	
2007		-Sichuan to Shanghai gas pipeline construction begins -NDRC's Natural Gas Utilization Policy ann., restricts baseload power use -centre: accelerate closure of small (<50MW), old, or inefficient thermal generation -Energy development plan of 11th five year plan annoucned -Nuclear Power Mediun to Long-Term Development Plan	-central target: quadruple 2000 per capita GDP by 2020 -SERC ann. new regulations for grids to include renewable-produced power -Bureau of Statistics and Energy Bureau revise historical balance tables -Green Building Labelling -NDRC ann. National Climate Change Strategy	-PetroChina listed in Shanghai -new Foreign Investment Catalogue encourages clean energy technology, >600MW power plants and equipment, railway equipment, and grid investment, restricts energy intensive industry, removes regional priorities
2008	- National Energy Commission est. -Energy Bureau reorganised	-comment period ends for draft Energy Law -Second West-East gas pipeline construction begins (Xinjiang-Guangzhou)	-amended Energy Conservation Law est., broadened to include transport and construction sectors, evaluates local government performance	-central government subsidises Sinopec and PetroChina for refining losses -tariffs raised for power and petroleum prices to reflect higher fuel costs

27.1 Major developments in energy policy (2001-2008)

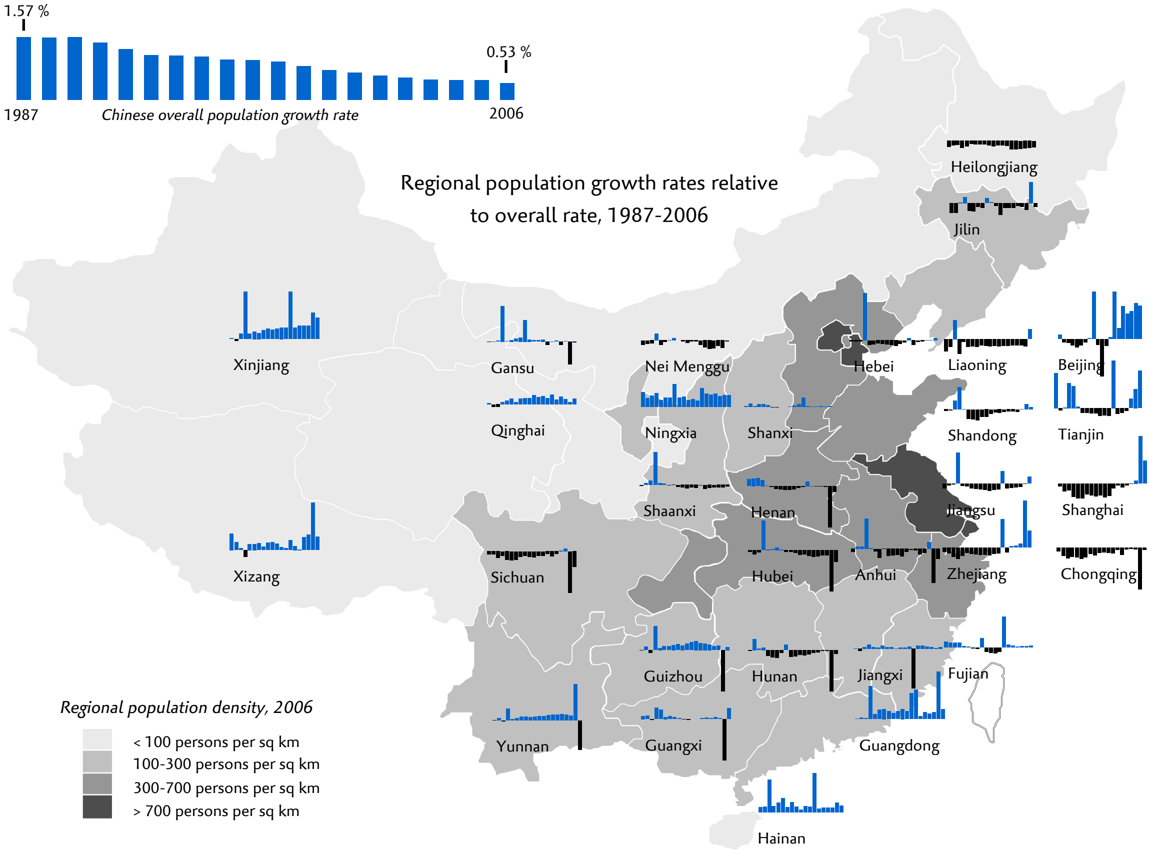
APERC 2008 and other sources [see References]



28.1 **Economic growth**

APERC 2008

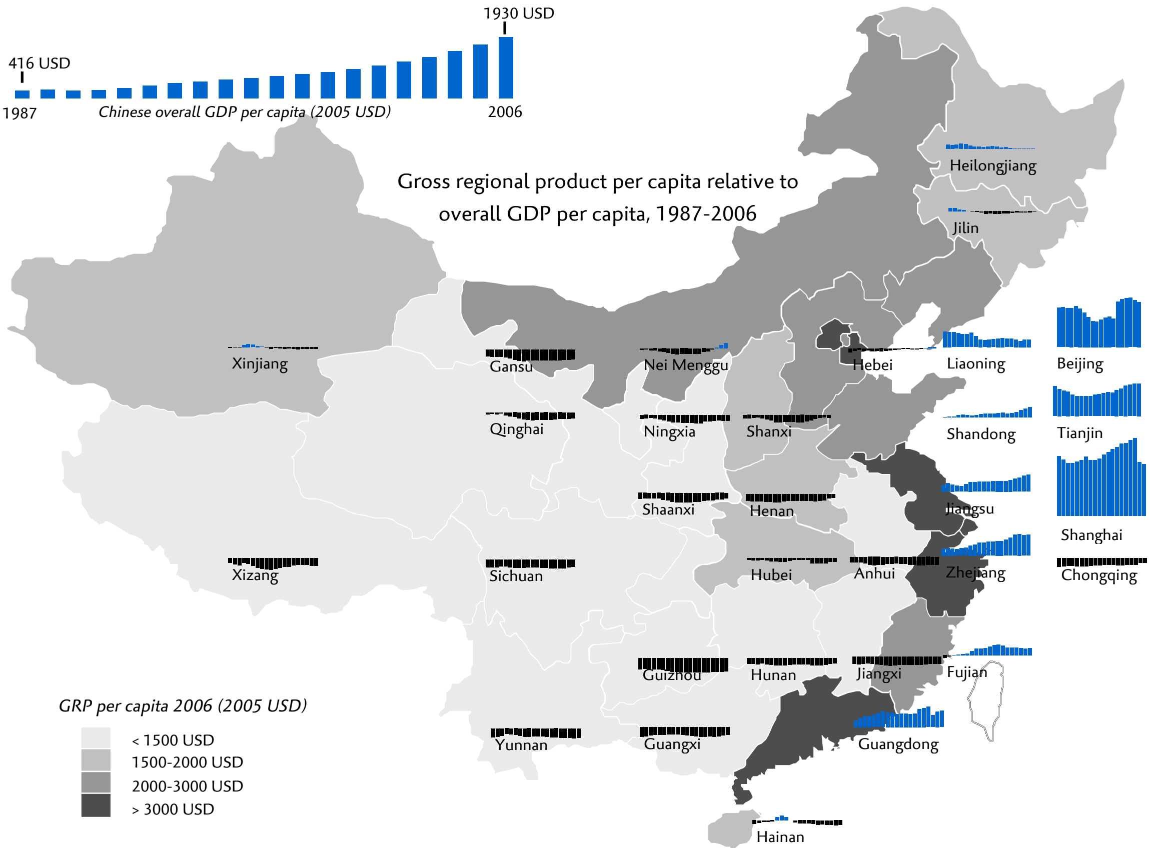
- Overall real GDP growth rate was robust following a swing from the late 1980s to early 1990s.
- Regionally, the eastern coastal provinces generally grew faster than the overall economy average.
- The regional economies of Guangdong, Shandong, and Jiangsu are among the largest, each exceeding 200 billion USD, while Sichuan stands out in the southwest.



29.1 **Population growth**

APERC 2008

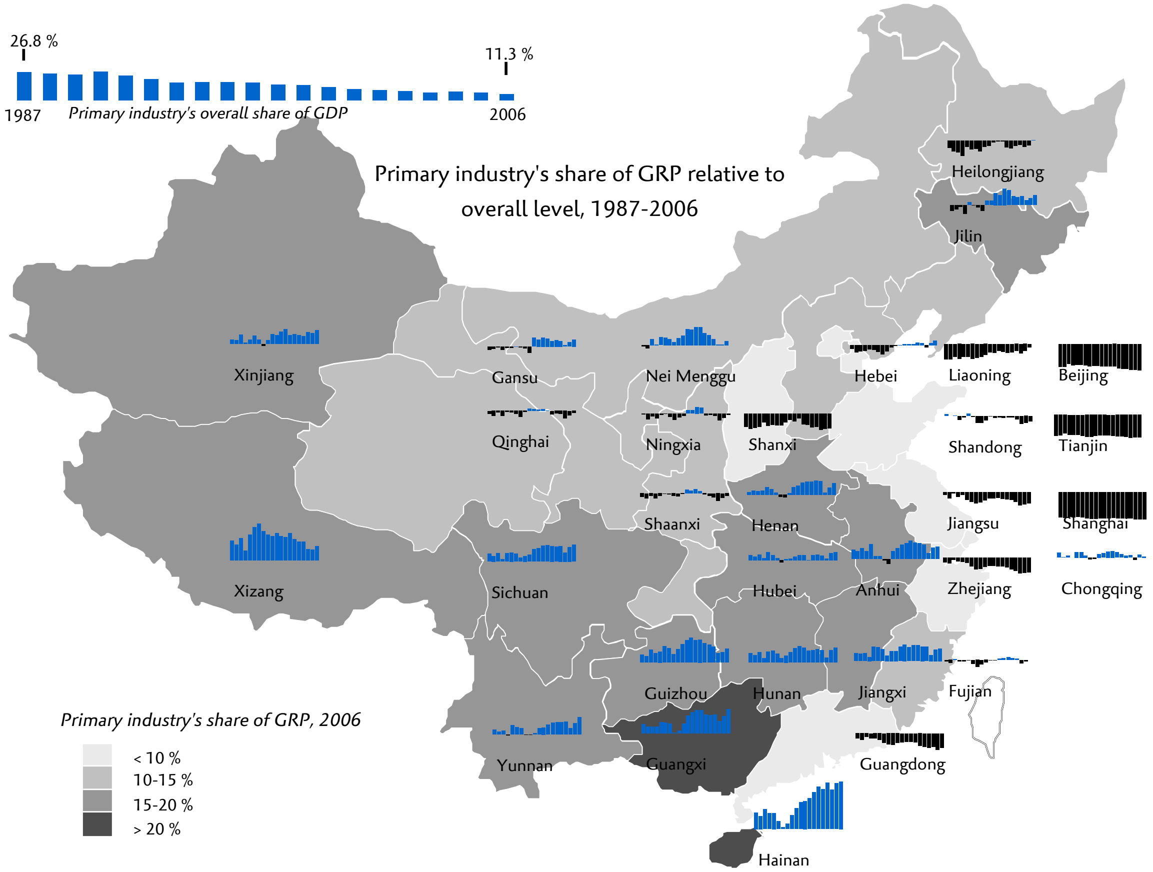
- Chinese overall population growth rate steadily declined from 1.57 percent in 1987 to 0.53 percent in 2006.
- Regionally, some variation in population growth can be attributed to inter-provincial migration.
- For example, in Guangdong, the locus of early economic reforms and continued rapid economic growth since the early 1980s, in-migration was high. The same was true of urban coastal centres such as Beijing, Shanghai, and Zhejiang in more recent years.
- The less densely populated western regions also saw relatively higher population growth as a result of higher birth rates and resource-based migration.
- Population densities are lowest in the west and north and highest in the built-up coastal centres of the east.



30.1 **GDP per capita**

APERC 2008

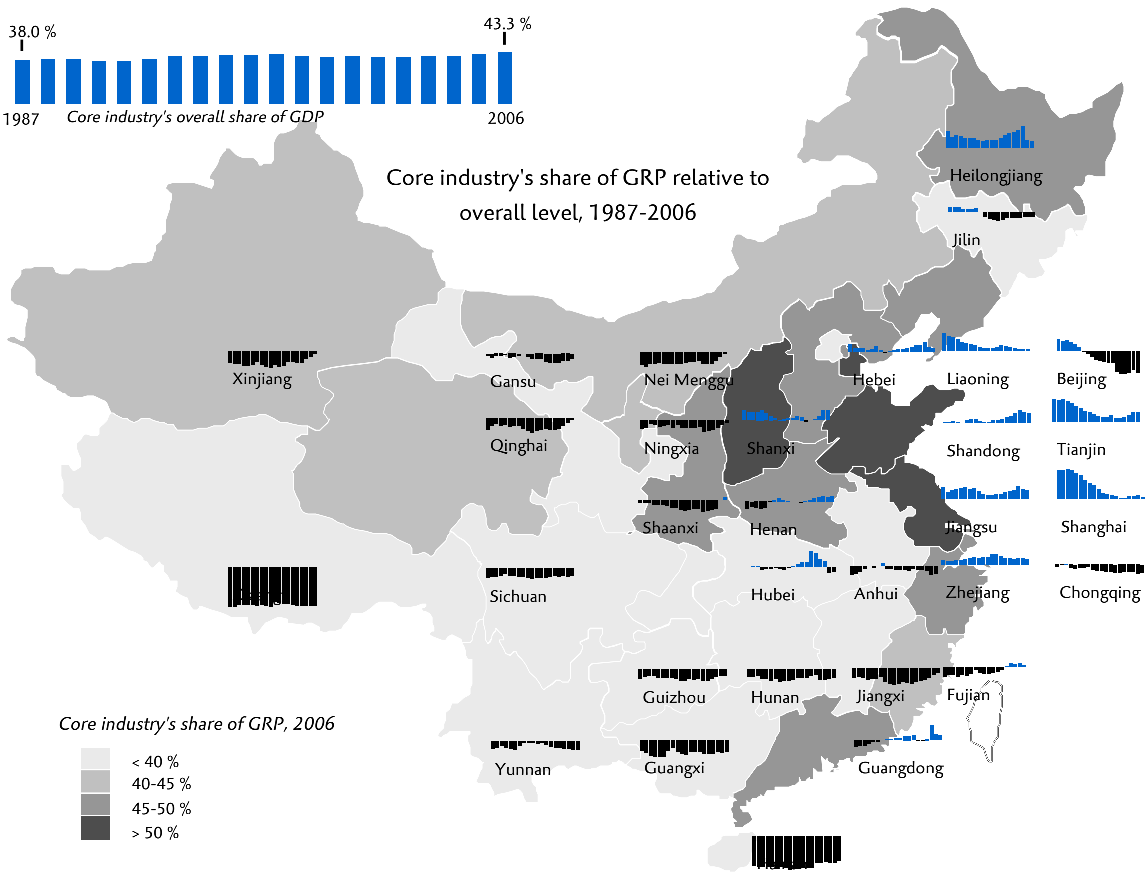
- Overall GDP per capita grew robustly, from 416 USD in 1987 to 1930 USD in 2006.
- Regionally, per capita economic activity in coastal areas was consistently above the overall economy average, particularly in urban areas.
- The highest per capita GRPs are found in Beijing, Tianjin, Shanghai, Jiangsu, Zhejiang, and Guangdong.



31.1 **Primary industry structural change**

APERC 2008

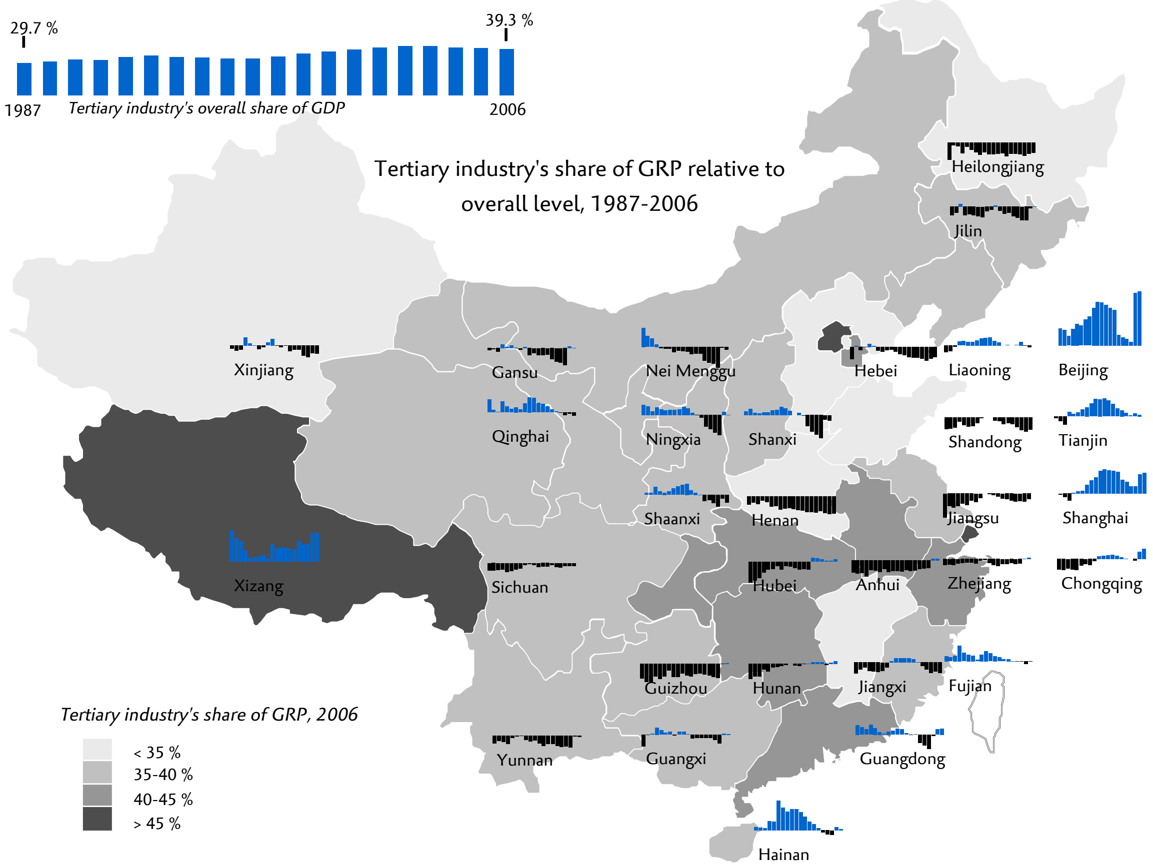
- Overall, primary industry's share of total GDP declined 15.5 percentage points from 26.8 percent in 1987 to 11.3 percent of GDP in 2006.
- Regionally, primary industry (including agriculture) represented a greater relative share of GRP in central and western China, and it represented a smaller share in the east.
- Primary industry's share of GRP is highest in Guangxi and Hainan and lowest in Shanxi.



32.1 **Core industry structural change**

APERC 2008

- Overall, core industry's share of GDP rose from 38.0 percent in 1987 to 43.3 percent in 2006, capturing approximately one-third of primary industry's decline in share.
- Regionally, core industry generally had a relatively lower share of GRP in central and western China and a relatively higher share in the east and northeast. In many regions where the share of core industry was relatively low, it began to converge up to the overall economy average share after about 2000. In Beijing, Tianjin, and Shanghai (and to some extent Liaoning), the share of core industry used to be higher than the economy average but gradually declined to the present.
- The share of core industry in total GRP is highest, above 50 percent, in Shanxi, Tianjin, Shandong, and Jiangsu.



33.1 **Tertiary industry structural change**

APERC 2008

- Overall, tertiary industry's share of GDP rose from 29.7 percent in 1987 to 39.3 percent in 2006, capturing approximately two-thirds of primary industry's decline in share. There was a slight decline in recent years, however, having peaked at 41.5 percent in 2002.
- Regionally, tertiary industry had a relatively higher share of GRP in the developed urban areas of Beijing, Tianjin, and Shanghai, but this converged towards the overall economy average through the late 1990s and early part of this decade. Hainan and Xizang, both tourist destinations, were also higher than the overall average. Northeast and central China had relatively lower shares from tertiary industry.
- Tertiary industry's share of GRP is highest in Xizang, Beijing, and Shanghai.

Energy Pricing

Before the onset of the reform period in 1978, China's energy industry operated under the "plan economy" system; pricing, investment, and allocation were all decided by the central government. By 1992, however, China had explicitly targeted the establishment of a "socialist market economic system", increasingly drawing market mechanisms into the energy industry. On the premise of "properly handling the relations among various interest groups" and "taking full account of the acceptability of all social sectors," the Chinese government has advanced and seeks to continue energy pricing reform in a "vigorous yet steady way," with the long-term aim that such pricing should reflect resource scarcities, changes in market supply and demand, and environmental costs.[a]

Considering both global and domestic energy challenges alongside growing environmental concerns, the *Eleventh 5-year guidelines* period (2006-2010) is critical for deepening energy price reform, with major measures to be based on the Outline *Plan for medium & long-term energy development, 2004-2020*. The primary objectives of such reforms are to move toward market-based energy pricing and to improve price supervision, as well as overall reform of the energy pricing regulation mechanism. However, China now faces energy challenges both international and domestic that might impede continued price reform: namely, high international oil prices and a domestic energy market structure and energy administration system still in transition. The following section offers an overview of Chinese energy pricing and policy by fuel, then drawing implications.

REFORM: TARGET AND RESULT

Through the reform period, energy pricing has generally become more market-based. Measures taken to enable this shift have included reform of government price setting institutions, the introduction of a diverse set of investors into the energy market, and taxation reform. Importantly, the central government has expressed its intent to use energy pricing as the primary tool in achieving a market-based energy system. And though there have been great changes in the pricing of coal, electricity, oil and oil product, and natural gas, full pricing liberalisation will require policies and measures to address China's imbalance in energy resource type, affordability to end users, regional diversity (in geographic distribution of energy production, energy demand structure, and economic development), and coordination between central and local governments as well as enterprises and other energy consumers.

Pricing reform of coal, electricity, and oil began before that of natural gas, and accordingly, their current levels of market liberalisation are different. Price reforms of coal and to some extent, electricity, which have generally had stronger supply capacities, have progressed most rapidly; complete price liberalisation of coal was achieved by 2002. Price reform of oil and natural gas, however, which have closer connection to residential end users, has posed more of challenge; today, natural gas is one of the few remaining commodities which are still priced by the

Recent significant energy pricing reform measures during the Tenth 5-Year period, from 2001-2005, included:

- Launching the *Power-coal price linking mechanism* aimed at relieving supply shortages of thermal coal and allowing power prices to be more market-based
- Initiating *Two-part power generation pricing* and *direct power purchase* pilot programmes
- Issuing the *Peak/valley, adequacy/shortage, and preliminary establishment of transmission power pricing system* to account for trans-provincial and regional power transmission such as with the West-to-East Power Transmission Project and the Three Gorges Dam
- Holding the *Initial public hearing on the adjustment of residential power prices*
- Completing the *Linking system for crude oil and product price with the international energy market* to improve the competitiveness of domestic oil companies
- Initial implementation of market net back pricing method through the *Cost-plus and market net-back combination pricing method* on specific projects such as the West-to-East gas project's ex-plant, transportation, and sales prices

35.1 Recent energy pricing reform measures

[a] *State Council 2007.*

Main policies in the fourth stage of energy pricing reform (2002-2007) included:

▪ *Implementing measures for generation-grid price separation* (May 2003)

▪ *Power price reform plan* (July 2003)

▪ *Pilot of two-part power generation pricing system* (April 2004)

▪ *Coal-power price linking system* (December 2004)

▪ *Provisional measures for the administration of the electricity generation price measures, T&D price measures and end-users price measures* (March 2005)

▪ *Coal-heat price linking system* (December 2005)

▪ *Reform pricing mechanism & recent proper improvement for the ex-plant price of natural gas* (December 2005)

▪ *Comprehensive reform plan for oil pricing* (March 2006)

▪ *Opinion on completing differential power pricing* (September 2006)

▪ *Provisional adjustment measures for NRE power pricing* (January 2007)

▪ *Provisional administration measures for city heating pricing* (June 2007)

central government[b]. In fact, end-user prices involving people's livelihood in the fields of power and heating continue to be set by the government, whereas even the ex-plant prices of natural gas and oil products are government-guided.

Of course, China's energy pricing reform, just like its whole economic development, has experienced fluctuation. Historically, stronger price-adjustments have been implemented in periods when energy supply has lagged demand. That is, the main driving force for pricing reform in China is the rapid growth and huge scale of energy demand.

In the early stages of reform, rocketing energy demand generated by economic growth created a sense of urgency to loosen the price setting system so as to provoke energy producers' aspirations and reduce their losses. The "Dual-track" system was thereby adopted across most energy sectors, establishing a "within-plan/quota" price for mandatory production and a (generally higher) "above-plan/quota" price for non-mandatory production.

The central government's emphasis on energy pricing reform has varied over different time during the reform period. The first stage, in the early 1980s, mainly adjusted the existing low prices of that period. The second stage, during the mid to late 1980s, gradually set various types of prices, eliminating the single pricing system. The third stage, from 1992-2002, standardised pricing management among regions and government bureaus. And the fourth stage, from 2003-2007, focused on improving the fairness and competitiveness of prices.

Pricing reforms have dramatically affected real-world energy prices in China. For example, in the Huadong region, the price of coal underwent an annualised average increase of about 1.4 percent from CNY 211 per tonne in 1997 to CNY 239 per tonne in 2004; over the same period, the price of electricity rose by about 6.6 percent annually from CNY 0.312 per kilowatt-hour in 1997 to CNY 0.5 per kilowatt-hour in 2004; diesel by 7.6 percent annually from CNY 2080 per tonne in 1997 to CNY 3564 per tonne in 2003, and that of gasoline by 8.7 percent annually from CNY 2230 per tonne to CNY 4100 per tonne.[c]

36.1 Recent energy pricing reform policies

REFORM: STATUS-QUO AND FEATURES

Continued reform of Chinese energy pricing into the future will continue to build on past success in developing comprehensive new pricing regimes that redirect macroeconomic regulation toward a fair, transparent, and legally-based system of indirect control and supervision, so as to give rise to a more diverse range of market players. This process has historically been and will continue to be specialised to the conditions of different energy sources.

COAL SECTOR

From 1978 to 2002, price of coal gradually liberalised, with the exception of thermal coal and state-owned mine production which continued to use the government guidance price. This practice continued through 2001, even though price controls on other types of

[b] *IEA 2002*

[c] *Dan Shi 2006; Growth rates are in real terms while prices are the regional integrated price expressed in nominal terms.*

coal had been completely liberalised since 1994. From 2002-2006, two attempts were made to increase electricity prices by establishing a coal-power price linking mechanism. And though such reform has not yet been fully realised, the signal provided by such efforts has nevertheless contributed to smother and more stabilised coal price trend. Similarly, the coal-heat price linking mechanism was implemented to make heat pricing more market-based. Under this system, the ex-plant heat price is linked with coal price, so that when the coal price increases by more than 10 percent, the ex-plant and sales prices of heat are adjusted correspondingly so that heat producers are subsidised 10~30 percent of the coal price rise.[d]

Power Sector

In recent years, a number of different departments have shared responsibility for power industry regulation. The State Electricity Regulatory Commission (SERC) is primarily responsible for planning power pricing reform, a task which is sometimes shared with the Power Sector Reform Working Group (PSRWG) which was established by the State Council in 2001; the Department of Prices of NDRC dominates pricing issues in electricity sector reform; the Ministry of Finance (MOF) decides certain financial rules and cost standards for electric enterprises; the State-owned Assets Supervision and Administration Commission (SASAC), established in 2003, exercises ownership responsibilities over state-owned enterprises (SOEs), including those which engage in power generation and transmission. In addition to central government bodies, province-level Economic and Trade Commissions provide local sector supervision and co-ordination.

Pricing reform has been ongoing in the power sector over the past decades and continues today.

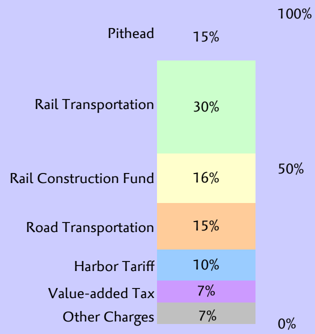
Before 1985, the Chinese government uniformly constructed power projects and managed power price. This mandatory-price system set the end user sales price rather than providing on-grid power tariffs.

However, due to the rapid growth of the Chinese economy and slow development of the power industry, there was serious power deficiency. Thus, in 1985, China implemented a policy of power plant construction through capital raising along with a system of multiple power prices, so as to encourage broader investment in the generation sector:

- Firstly, power price was adjusted according to the loan and interest conditions of capital raised for construction.
- Secondly, power price was linked with fuel and transportation tariffs to reflect changing costs.
- Thirdly, a fee of CNY 0.02 per kilowatt-hour was established to fund local power construction.

Despite such strong promotion of power industry development, this policy nevertheless led to a disorderly price system incorporating "new prices" for "new power plants", "old prices" for "old power plants", and different prices for different power plants and even different power generation units. Over time, it also led to intentional increases in power

The end-user coal price consists of a number of different charges and fees, of which the transportation fees can be most significant. For example, a coal consumer in Nei Menggu in 2004, located near cola-producing regions, would have paid a pithead price of CNY 40 per tonne; the Qinghuangdao FOB price for that same coal, however, would have been CNY 260 per tonne. This price difference of CNY 220, would have included a rail transportation fee (30 percent), railway construction fund (16 percent), road transportation fee (15 percent), harbour tariff (10 percent), VAT (7 percent) and other charges.



37.1 **Coal FOB price composition (2004)**

Fubin Yue 2004

[d] *Heat price consists of three parts: ex-plant price, transportation price and sales price.*

price, escalating power construction costs, and haphazard power plant construction.

From 1997, China began to implement operational period power pricing, shifting from a capital cost-plus based system to one based on the average cost of the "social advanced level". At this time, China also standardised the rates of return on capital investment for power construction.

In 2002, power generation enterprises were separated from power network enterprises. Under this reform, independent power generators established on-grid power prices for the power network, which in turn set the power sales price for end users. Except for on-grid prices determined through government-hosted bidding and "new energy" power generation projects[e], a uniform on-grid power price benchmark was adopted for new generators operating in the same area, and was gradually expanded to power generation companies using the existing pricing system.

[e] *Primarily wind, biomass, and small- to mid-sized hydro.*

As of 2008, there is no corresponding pricing mechanism on power transmission and distribution.[f] Instead, the power transmission and distribution price is mainly reflected through the difference between the power sales price and the on-grid power price set by the government. Moreover, there are significant differences in the power sales price and on-grid power price among different regions.

[f] *With the exception of some long-distance power transmission projects, such as the West-to-East Power Transmission Project.*

End-user prices are stratified by category. The Chinese government sets different price standards for different use types, including: residential living, non-residential lighting, commercial, general industry, large industry, agricultural production, and agricultural drainage and irrigation in poor counties. Power prices for agriculture and residential use are protected by relevant policies; for example, residential prices can be increased only through public hearing. Large industrial user with high energy consumption have benefited in the past from preferential government-set power prices so as to stimulate economic growth, but this preferential policy has been cancelled in favour of a differential power price in recent years.

In 2003, The State Council prepared the *Reform scheme for power price* to determine the overall direction for market-based power price reforms and in 2005 issued various matching implementation rules to specify in detail these reform measures, focusing on the generation, transmission/distribution, and end-users price.[g] Described below, some elements of these plans are already in practice, but as of 2008 most reform measures have few substantive results.

[g] *Including the "Provisional regulations on on-grid power price", "Provisional regulations on power transmission & distribution price", and "Provisional regulations on power sales price".*

38.1 **Electricity pricing chain**

Generation price

To be based upon generator status. Those generators participating in the competitive market are to receive both a capacity charge determined by appropriate price regulation bodies outlined and an energy charge determined by market competition. Prices for generators not participating in the competitive market are to be set by local and provincial governments in consultation with central price regulatory bodies according to economic life span. On grid tariffs are to be adjusted so as to reflect demand and supply in times of fuel price fluctuation. Other anticipated reforms to the generation tariff seek to further reflect the type of technology and province-specific costs of installing and operating such technology.

Transmission and distribution price

To be set by the central government to reflect costs, acceptable returns, and taxes, as well as "fair sharing of the burden" and should vary for distribution services provided through public grids or for dedicated and other ancillary services.

End-user price

To be determined by the central government to once again reflect "fair sharing of the burden" as well as to manage electricity demand and contribute to other policy objectives with the overall goal of more directly linking the end-user price to the generation price—an elusive objective in recent years. The end-user price is to include four elements: (1) on-grid price; (2) electricity loss during transmission; (3) transmission price, and; (4) related government-administered fees. Further reforms aim to develop different tariff classes for different end users, differentiated by voltage class: residential; agricultural production, and; industry and commerce. Residential agricultural production user prices are to be calculated per kilowatt-hour. Industrial and commercial or other users with a consumption capacity of 100 kilowatts or more are to pay a consumption-based kilowatt-hour tariff as well as a capacity-based basic electricity tariff.

The 2005 *Regulations on on-grid power prices* also provide for peak and valley tariffs as well as seasonal tariffs in appropriate consumption areas. Elements of this have already been implemented on a regional basis. The *Time-of-day electricity pricing policy*, for example, stipulates that peak price be charged during the summer (or winter) electricity consumption peak in Beijing and other large cities; a peak/valley price is currently determined by linking electricity generation and sales in five areas, including Jiangsu province. Similarly adequacy/shortage power pricing has been implemented in six areas rich in hydroelectricity, such as Hunan province. The *Differential electricity pricing policy*, meanwhile, has been implemented on a trial basis in six energy-intensive industries (such as electrolytic aluminium, ferroalloy, calcium carbide, and caustic soda).[h]

[h] *China Databar 2006*

	PRICE (CNY/KWH)	
NORMAL END USERS	0.61	
END USERS WITH TIME-OF-DAY AMMETER	6:00 – 22:00	0.61
	22:00 – 6:00	0.30

40.1 **Residential electricity sales price in Shanghai**

Shanghai Price Information Service Network

Current problems in power pricing include:

- Coal prices have been loosened in China while power price is controlled, making it difficult to implement a coal-power price linking mechanism. After the first such linking attempt in May 2005, Chinese power prices increased on average by CNY 0.0252 per kilowatt-hour; after the second adjustment in May 2006, power sales price increased slightly, but increasing coal contract prices for power plants have outpaced such adjustments; the third attempt has been delayed due to high inflation. The relationship between coal and power pricing has become increasingly prominent, so as to influence the supply and demand of power.
- There is no pricing mechanism for power transmission and distribution, to the detriment of development and structural optimization in the economy's power network.
- The current end-user power price mechanism is inefficient. Different power sales prices for different use types distorts cost structures, and thus power price does not accurately reflect and regulate the balance of supply and demand in the power sector.

OIL SECTOR

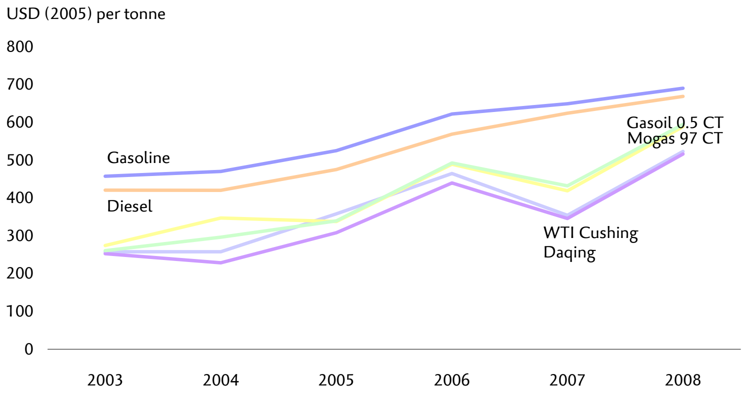
Transformation of the regulatory system in the oil industry began in 1982 with general goal of weakening industrial administration and strengthening enterprises' independence. The abolishment of Ministry of Energy in 1993 ended industrial administration of the oil industry, instead delegating administration to the state-owned oil companies. But from 1998 on, the separation of enterprise administration and government function became clearer in the oil sector, with CNPC, CNOOC, and Sinopec relinquishing these government functions that they had previously exercised as state oil companies. Presently, the main regulatory departments overseeing the oil sector are the National Development and Reform Commission (NDRC), Ministry of Land and Resources (MLR), Ministry of Housing and Urban-Rural Development (MOHURD), Ministry of Commerce (MOC), State Administration of Work Safety (SAWS), State Administration of Taxation (SAT), and Ministry of Environmental Protection (MEP).

Oil pricing experienced three stages of transformation over the reform period. The first stage, in the early 1980s, replaced the single planned price with a dual-track price. The second stage, in the mid-1990s, cancelled the dual-track price in favour of a uniform oil price based on oil quality. The third stage, from June 1998, linked the domestic price of crude oil with international crude prices.

At the beginning of this third stage, the Chinese domestic base price of crude oil for the following month was set by the former the State Development Planning Commission (SDPC) according to the current monthly average Singaporean Minas price of crude oil, with an additional margin then added to this base price. The base prices of gasoline and diesel were set according to the average FOB Singapore price, on top of which was added the transportation fee to China, insurance premium, tariff, and retail profit to arrive at the standard price. From this, wholesale prices were determined by deducting 5.5 percent. Enterprises could then raise or lower this price by 5 percent when necessary according to supply and demand conditions in the domestic market and based on the government guidance price.

From March of 2001, SDPC ceased publishing the crude oil base price, which was instead calculated and confirmed month-to-month by CNPC and Sinopec. In 2001, the oil product pricing system was also modified from this single link with Asian market to a composite link with three major markets in Asia, Europe and North America. Under the updated system, the domestic oil product price was no longer directly related to the international oil market but was only adjusted when international oil price changes exceeded an amplitude of 8 percent. When adjusted, final gasoline and diesel sales prices could then increase or decrease by 8 percent.

This oil product pricing system was modified once again following the 2003 SARS outbreak. Since then, the central government has adjusted oil product prices on an *ad hoc* basis in consideration of international oil prices as well as the internal economic development situation and social affordability. And so though the tools used to do so have changed, over time such reforms have gradually led to harmonisation between China and international market oil product prices. **[41.1]**



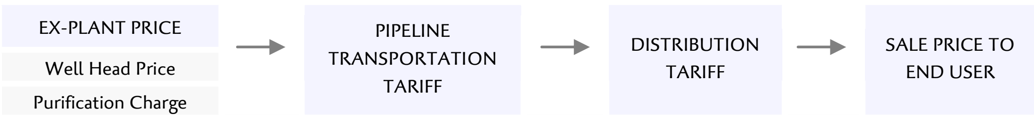
41.1 **China oil product price (2003-2008)**

Note: Prices are averaged over January of each year. CT refers to Chinese Taipei.
International Petroleum Economics (2003-2008)

Natural Gas Sector

The natural gas sector follows a parallel pricing system: a traditional "old price" applies to projects that were completed before 1995 while a "new price" applies to projects completed in 1995 or later. This system, the result of a 1997 reform referred to as "new price for new line," established an end-user price based on a cost-plus approach and is composed of three elements as described below.

Transmission of natural gas from well-head to users includes: (1) exploration; exploitation and purification of gas field; (2) transportation of gas via long-distance pipelines, and; (3) gasification and distribution of urban gas. The price of natural gas is composed of three corresponding parts: (1) the well-head cost & purification fee charged by the gas field (including project cost, various taxation including resource tax, a value-added tax, add-on taxes such as the municipal construction fee and education cost fee, income tax, and profits); (2) the pipeline transportation tariff charged by long-distance transportation pipeline companies (determined according to consumption region, pipeline diameter, transport distance, taxes such as business tax, customs tax, income tax, and profits), and; (3) the local distribution tariff charged by local authorities. At present, these three parts of price are largely managed by local governments and enterprises in consultation with the central government (particularly NDRC). Ex-plant price (well-head price plus purification fee) is set by NDRC, pipeline transportation tariff is set through the approval of NDRC for the suggested fee submitted by local price control bureaus, and local distribution tariff is set directly by provincial price control bureaus based on a cost-plus approach.



42.1 **Natural gas pricing chain**

Well-head price itself is divided into three categories: a within–quota price, which is for the volume of gas sold within the allocated quota; an out-quota price, and; a contract price which is freely negotiated between producers and consumers.

In 2005, NDRC issued the *Notice on reforming pricing mechanism & recent proper improvement of the ex-plant price of natural gas*. According to the notice, residential, commercial, and small industrial users who receive gas through an urban natural gas pipeline network were combined into a single category. Gas price categories were then simplified into gas for chemical fertilizer production, directly supplied industrial gas, and urban gas. Furthermore, ex-plant prices of natural gas were divided into two categories based upon ex-plant gas production conditions and end user affordability. Category one gas includes existing natural gas production in oil/gas fields sold at planned or near-planned prices, and all other "planned" gas production, including all gas in Sichuan-Chongqing, Changqing, Qinghai, and Xinjiang oil fields (excluding natural gas in the West-to-East Gas Project) and current planned natural gas in Dagang, Liaohe , and Zhongyuan oil field. Category two gas includes all other natural gas.

IMPLICATIONS

HOW HAS THE ENERGY PRICE LEVEL BEEN INFLUENCED IN CHINA?

Energy pricing reform in China has taken place against a backdrop of both rapid industrialisation and a broader economic system transformation (that is, from a planned to market economy). Such overlap significantly complicates the reform process. Certain characteristics of the Chinese energy system have a persistent baseline influence on energy price, namely diversity in energy resource geographic endowment and variety, diversity in regional development, divergence across energy industries, and variation in government policy across time. For example, the case of natural gas development in China illustrates the influence of diversity in energy resource endowment.

Demand for natural gas in China is growing more quickly than for coal in part because of increasingly strict implementation of environmental regulations. On a heat-value basis, the 2002 price ratio between coal and natural gas was roughly 1:1.35 globally, but 1:3.00 in China. Price, therefore, is a significant obstacle to expanding the natural gas market in China. To address this, the Chinese government plans to grant favourable financial and tax support for domestic natural gas production and for use in areas such as residential heating, while restricting its use for large scale power generation.

43.1 Influence of inter-fuel competition on natural gas price

Zhou Fengqi and Wang Qinyi 2001

Energy prices through the APEC region are influenced by both domestic and international factors: on one hand, changes in international prices are generally eventually reflected in domestic prices; on the other hand, various domestic stakeholders often have different targeted energy prices. In China, central government energy pricing policy seeks to reflect a wide range of economic, social and political goals while local governments generally seek to boost local economic development as much as possible while implementing central government policies. Meanwhile, industry associations seek to align governmental and industrial benefits and individual enterprises seek to increase market share and profits so as to ensure financial viability.[i]

Current energy price distortions reflect the incomplete nature of the pricing system. For example, coal pricing has not traditionally but is now beginning to include external costs (such as those for resource depletion and environment protection) and other implicit expenses (such as those for depreciation and safety). One estimate for coal production in Shanxi put the excluded cost at CNY 97.33 per tonne (considering such hidden costs as resource depletion, water use, landslides, mine-based runoff pollution and land use in addition to other human and infrastructure costs), about half of the existing production cost.[j]

[i] *APERC 2000*

[j] *Current reform plans in China aim to raise resource use tariffs for coal mines economy-wide in part to improve energy efficiency. Additional revenue generated will be used to expand coal mine exploration, upgrade environmental protection facilities, and improve miners' living conditions.*

WHAT IS THE CORRELATION BETWEEN THE WORLD ENERGY PRICE AND CHINESE DOMESTIC ENERGY PRICE?

Over the course of the reform period, and particularly in recent years, coal price has changed dramatically from its long-existing low level, oil product price stabilised along an upward trend, and adjustment of electricity price has helped relieve the contradiction between electricity supply and demand (namely, shortages). The oil and natural gas pricing mechanism has gradually moved to reflect changes in international market prices as well as domestic market supply and demand, and electricity tariffs increasingly ensure that generation and

In May 2008, the No.90 gasoline price of Shanghai Petrochemical (SHI) was approximately CNY 5480 per tonne while No.92 gasoline on the Singapore market reached CNY 9860.42 per tonne, for a gasoline price gap of CNY 4380.42 per tonne. As for diesel price, No. 0 diesel of SHI was CNY 5070 per tonne while 0.05 percent diesel in Singapore reached CNY 10403.61 per tonne, for a diesel price gap of CNY 5333.61 per tonne.

44.1 Domestic and international oil product price gap

First Financial Daily, May 28 2008

selling prices are established by market competition. Generally speaking, the correlation between the world price and Chinese domestic price has become stronger over time.

However, pricing regime reform cannot be achieved in a single step. There are a number of reasons for this, such as the need to ensure macroeconomic developmental stability and smooth allocation of resources. One of the main concerns, though, is for equity. Disadvantaged, rural, and low-income urban residents are easily impacted by rapidly rising energy prices even given China's modern economic and development success. Considering this, adjustments in energy tariffs, taxation, subsidies, and laws and regulations will continue to be needed through the short to mid term. But such a task is not easy. Over the past two years, the rise in consumer energy tariffs has lagged that of fuel prices and largely avoided dampening overall energy demand. When authorities have tightly limited price hikes economy-wide for fear of sparking excess inflation, and where applicable rules are unable to achieve optimal timing and magnitude of tariff adjusts, market pressures have challenged tariff management.[k]

Moreover, the pace of market liberalisation is not synchronised across different energies, resulting in sometimes incongruous pricing mechanisms. For example, thermal coal, representing nearly half of total coal consumption in China, was scheduled to be liberalised in 2002, but this was not actually realised due to a number restraint factors. Other coals, however, representing an equivalent share of total coal consumption, are already market-based. Implementation of the coal-power price linking mechanism remains a challenge.[l]

Oil product price in China is set through somewhat of a hybrid system, not yet completely through market competition but rather through a supervised "guidance price" issued by price administration authorities. So, with recent large fluctuations in crude oil price, international oil product prices may rise significantly, but this is not necessarily reflected on the domestic market. This can result in product supply shortage on the domestic market because of such a margin between its domestic and international price. And because refining cost profiles vary among different oil products, supply shortages vary as well under continued constant or rising product demand, as observed through the second half of 2007. Understanding such pressures, reform of the oil product pricing mechanism will be the focus and challenge of the next stage of deepening Chinese energy price reform.[m]

[k] *ERI 2005*

[l] *The NDRC recently announced a freeze on domestic thermal coal prices from June 19, 2008 to December 31, 2008, to be implemented by setting the contract price as of June as the maximum price. Concurrently, NDCR also announced that electricity tariffs would be lifted by CNY 0.025 per kilowatt-hour from July 1, 2008.*

[m] *On June 20, 2008, the benchmark gasoline and diesel oil retail prices were lifted by CNY 1,000 per tonne, and that of aviation kerosene by CNY 1,500 per tonne. Prices for natural gas and liquefied petroleum gas, however, were left unchanged. As a result, retail benchmark prices of gasoline reached CNY 6,980 per tonne and diesel CNY 6,520 per tonne, up more than 16 percent and 18 percent respectively. The NDRC said the oil price adjustments was made to ensure domestic supply by diminishing the gap between continuously rising international crude prices and state-set domestic product prices. CBN 2008*

CHINA'S STORY OF COAL

Coal is both China's most abundant and most used energy resource, and it is therefore the most important fuel for China's energy security, economic prosperity, and future development. What happens in the story of coal affects all of China, and in an increasingly global economy, the world too. This section lays out the most important drivers and trends in the Chinese coal industry.

The first section examines coal demand and supply trends of the last decade so as to understand the underlying drivers influencing recent double-digit coal growth. Coal production has generally kept pace with demand through the reform period, but bottlenecks exist, particularly in transport, and these are influencing supply security and import-export trends. The next section, therefore, identifies issues facing the industry, with a focus on coal transport. The final section looks at future options for coal in China. Challenges remain despite past successes, as China's economy depends on efficient, timely, and stable supplies of coal.

China's coal market is the biggest in the world, producing and consuming almost 40 percent of the world total (39.4 percent and 38.6 percent respectively).[a] In 2006, China burned 1377 millions tonnes oil-equivalent of coal[b] to provide 70 percent of China's primary energy and 80 percent of its electricity.

[a] *BP 2007*

[b] *APERC database 2008; In raw units, China's 2006 coal demand totalled 2.39 billion tonnes according to China Energy Statistical Yearbook, NBS 2007.*

DEMAND TRENDS

Since 2001, China's coal consumption has increased at an annualised rate of about 11.8 percent per year, reaching a high point of 19 percent growth 2003. China used 75 percent more coal in 2006 than just 5 years before.[c] Globally, China's growth in coal consumption accounted for 72 percent of incremental coal consumption growth in 2006.[d] And strong growth in coal demand is expected to continue. Some officials in the industry project coal demand to surpass 3 billion tonnes by 2010.[e]

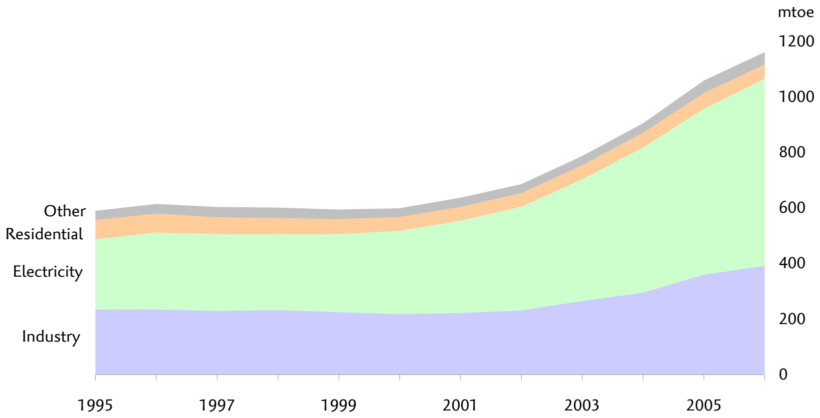
[c] *74.9 percent between 2001 and 2006.*

[d] *BP Presentation 2007*

[e] *China Coal Industry Association 2008*

The share of coal in Chinese primary energy consumption has increased in recent years to over 77 percent.[f] The biggest drivers of such demand (and of overall energy demand) are China's double-digit growth in electricity production and industrial output – both heavily reliant on coal. Electricity and industry are the major coal consuming sectors, making up 50 percent and 43 percent respectively of coal demand in 2006. **[46.1]**

[f] *77.2 percent of total commercial primary energy demand in 2005, APERC database 2008.*



46.1 **China's coal consumption (1995-2006)**

APERC 2008

ELECTRICITY

China's increasing demand for electricity and ensuing electricity production is the primary driver of coal demand, accounting for over three quarters of demand growth in recent years[g]. China's electricity production is growing 15 percent a year, and the power sector's coal use is growing just as fast.

[g] *Rosen and Houser 2007*

Electricity production surged recently as waves of large-scale thermal generators came online through the post-2002 power investment boom. When electricity demand surged in 2002 after holding steady for some years, generators struggled to meet demand, especially during the summer peaks. In response, both public and private actors invested heavily in the industry.

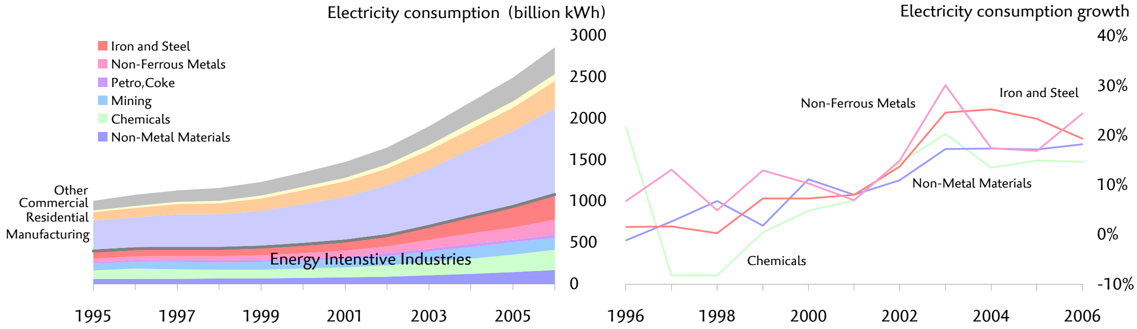
Over the same period, central policies encouraged the development of larger and more efficient generation units to replace older ones. Thus, recent units coming online have also been the biggest. By the end of 2006, there were 144 plants over 1 gigawatt in size.[h] Installed capacity grew rapidly through the Tenth 5-Year period, and in 2006 alone, China added a net 100 gigawatts of capacity, including over 80 gigawatts of thermal power. **[50.1]**

[h] *Huang Qilin 2007*

Both the high prices (and limited availability) of oil and natural gas and the need for fast development favoured coal-fired power over other technology. As a result, the share of coal in electricity's fuel mix grew from 76 percent in 1995 to 80 percent in 2006, and its share for thermal power grew from 94 percent to 97 percent.[i]

[i] *NBS 2007, APERC database 2008*

Contrary to popular perception, household electricity use is not driving demand, at least not yet. Residential consumption has maintained about 11 percent share of total electricity consumption. The fastest growth has been from industry, especially heavy industry which represents over 40 percent of electricity consumption. For example, the iron and steel industry averaged annualised 19 percent growth in electricity use and increased its share of final consumption from 8 percent in 2000 to 10 percent in 2006. **[47.1,2]**



47.1,2 **Electricity consumption by sector (1995/6-2006)**

APERC 2008, China Energy Statistical Yearbooks 1995-2007

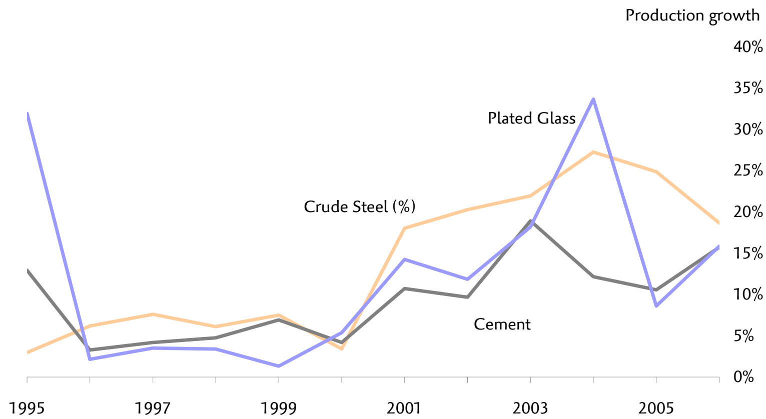
Electricity capacity and production will continue rising into the future. About 91 gigawatts of new capacity was added in 2007 to reach a total generation capacity of 713 gigawatts[j], and total capacity is expected to reach 840 gigawatts by 2010[k].

[j] *Liu Xiaoli 2008*

[k] *Huang Qilin 2007*

INDUSTRY

Because industry in China is a major consumer of both coal-fired power as well as coal itself, Chinese industries are not only driving strong electricity demand, but also final coal demand. The recent upturn in industrial production has been a major driver of coal consumption. While heavy industry maintained relatively stable production levels through the 1990s, the early 2000s marked a drastic turn of events, and some energy intensive industries began to experience double digit increases in production. **[47.3]**

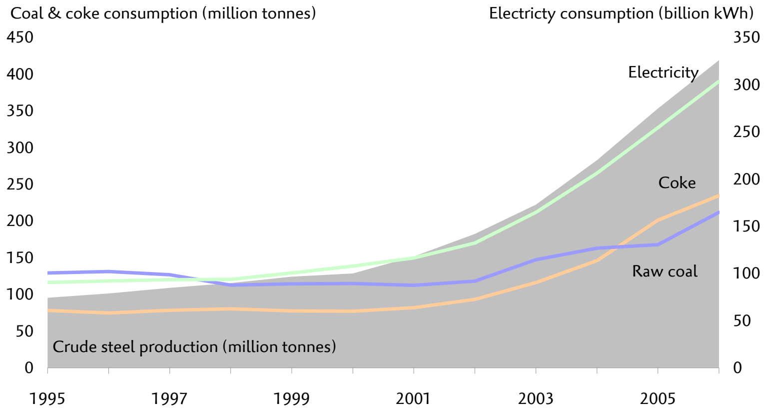


47.3 **Output growth of select energy-intensive products (1995-2006)**

APERC 2008, China Statistical Yearbooks 1995-2007

[l] *Net exports for steel products totalled 24 million tonnes in 2006, NBS 2007.*

The iron and steel industry is perhaps the best example of this. From 1995 to 2000, raw and rolled steel production grew at modest rates of 6 and 8 percent per year respectively. After 2000, however, the industry grew over 20 percent per year and production more than tripled by 2006. Within a short span of time, China went from an importer of steel to a net exporter.[l]



48.1 **Steel output & energy use (1995-2006)**

APERC 2008, China Statistical Yearbooks 1995-2007

[m] *Rosen and Houser 2007*

Energy intensity of iron and steel manufacturing, however, has improved significantly in the past decade, cutting by half or more. The same is true for many other energy-intensive industries, including chemicals, cement and glass, non-ferrous metals.[m] Each new steel mill, despite being more energy efficient, still demands more total energy, and given the high rates of growth in the industry, energy needs add up quickly. From 2000 to 2006, the iron and steel industry's coal and coke use averaged 11 percent and 20 percent annualised growth, respectively. **[48.1]**

SUPPLY TRENDS

RESOURCES AND RESERVES

[n] *BP 2007; According to China Coal Industry Association website, proven coal reserves amounted to 188.6 billion tonnes in 2002.*

China's heavy reliance on coal is rooted in a domestic abundance of coal resources and extensive reserves, especially in relation to other energies. China's coal reserves rank third in the world with 13 percent of the world's mineable coal, estimated at about 114.5 billion tonnes. In comparison, China has 1.3 percent of the world's proven oil and natural gas reserves.[n]

[o] *China Databar 2006; CCII 2005*

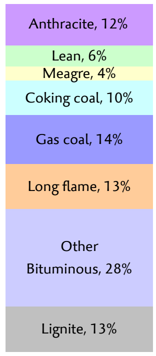
Furthermore, China's coal resources are estimated at over 5 trillion tonnes, with about 1 trillion tonnes in identified resources.[o] Despite these vast resources, proven reserves remain modest. Aware of this, the *Eleventh 5-year guidelines for energy development*, and other 5-year plans before it, encouraged further exploration of coal resources in China's top producing Sanxi region (Shanxi, Shaanxi and Nei Menggu) in hopes of expanding proven reserves. Into the future, a thorough and transparent assessment of reserves could contribute to improved resource planning in the coal sector both within China and the APEC region.

p *BP 2007*

q *ADB 2006*

QUALITY

Of China's coal reserves, about 55 percent is considered to be high quality coal (anthracite and bituminous) while the remainder is sub-bituminous and lignite.[p] **[49.1]** shows different coal types and their estimated share in total resources. Of coal mined in China, average ash content is estimated to be 28 percent and sulphur content 1.1 percent. Medium sulphur coal (defined as 1-2 percent sulphur content) accounts for 40 percent of coal use and high sulphur coal (over 2 percent) for 14 percent.[q]



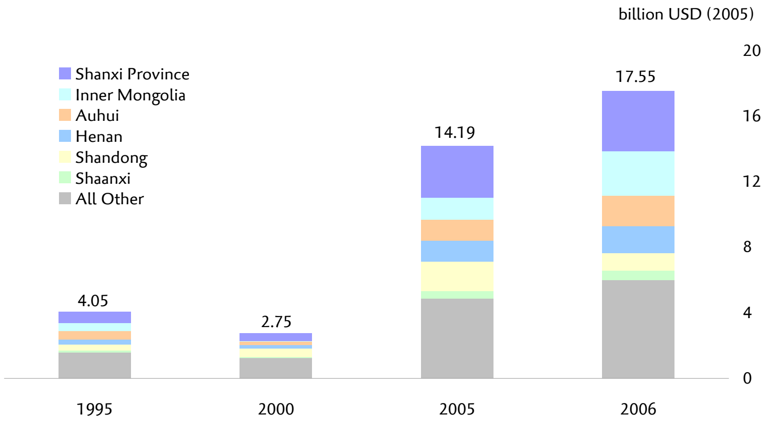
49.1 **Composition of coal resources by type (2005)**

Industrial Map of China Energy 2006

PRODUCTION TRENDS

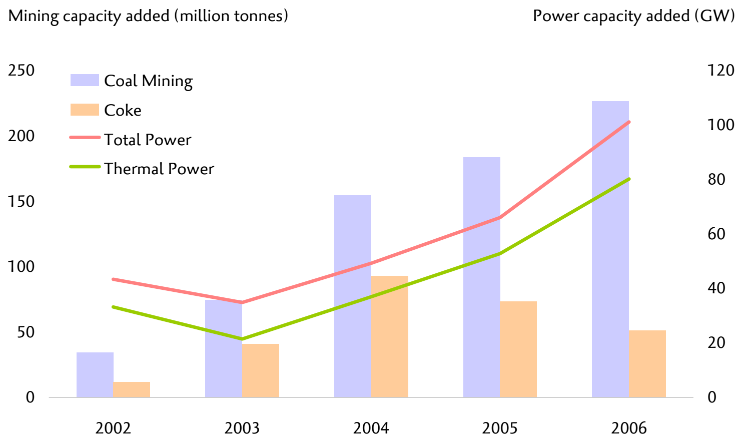
Following a sustained strong policy push, coal production has generally grown rapidly in recent years, supplying China's domestic demands and even allowing for export. Production dipped in the last years of the 1990s during the industrial and economic shifts of that period, but growth has been strong ever since, about 12 percent per year. Moreover, new production capacity and investments are on the rise as shown in **[49.2]** and **[50.1]**. In 2006, coal production reached 1,179 million tonnes oil-equivalent, up 9 percent on the year.[r] At current rates of extraction, China's proven reserves could support about another 50 years of production.

r *APERC database 2008*



49.2 **Investment in coal industry (1995-2006)**

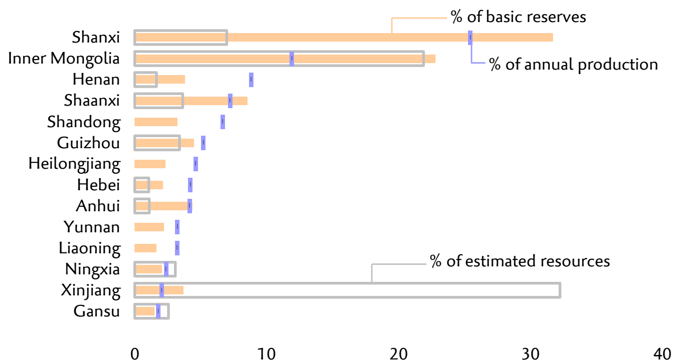
China Energy Statistical Yearbooks 2007



50.1 **Coal, coke & power production capacity added (2002-2006)**

China Statistical Yearbooks 2007, Huang Qilin 2007

An important characteristic of China's coal production and potential is the geographic distribution of both resources and production. One general trend is the broadening geographic demand for coal despite a more concentrated geographic supply. Five provinces now produce about half of China's coal, while a dozen others produce the remaining half. **[50.2]** describes the different production shares by province in 2006. Shanxi, Nei Menggu, Henan, and Shandong are the biggest producers. Two-thirds of China's coal resources, however, are located in just four provinces. As seen from **[50.2]** about one-third is located in far western Xinjiang alone, while another third are in Nei Menggu, Shanxi, and Shaanxi. Basic reserves of coal are primarily located in the latter three provinces, also called the Sanxi region. Current consumption, however, is skewed towards traditional production centres in more eastern areas less endowed with total resources **[55.1]**. This disparity has implications for the future potential of coal production, and for the transport or transmission infrastructure that will be necessary to fully exploit such reserves.



50.2 **Share of coal resources, reserves & production by province (2006)**

APERC 2008, Industrial Map of China Energy 2006

And as described above, coal demand is still growing at impressive rates. If such growth continues, China could encounter more coal supply bottlenecks, or even shortages, over the mid-to long-term given the geographic remoteness of significant portions of reserves and resources.

Historical Context

Coal production in China has undergone periodic under and over-supply in the reform period, with a tendency for the central government to issue policies and interventions during these times. Following initial economic reforms in the late 1970s, coal demand outpaced supply. With state-owned coal enterprises unable to sufficiently increase production[s], central leaders turned instead to local actors, opening up coal resources for local[t] investment to stimulate production in the early 1980s. Perhaps more effectively, a two-tier pricing mechanism for coal (one price for state-owned enterprises and the other market determined) was introduced creating favourable market conditions for local mines.

[s] *At the time, state owned enterprises (SOEs) were burdened with over-employment and provision of social services, generally operating at a loss.*

[t] *"Local" throughout this section refers to all operations below the provincial level, namely township, village and private enterprise. See following section on Industry Structure.*

These policies significantly affected the coal industry. By 1985, one-third of production came from locally-owned mines. Because local mines sold coal at a higher market-determined level while maintaining low production costs and overheads, SOEs were relatively less competitive. But the proliferation of local mines also introduced a suite of challenges, and subsequent central policies focused on regulation and reform of such enterprises. When China's economy overheated in the late 1980s, central leaders intervened by capping prices for coal and other raw materials, and coal production growth dampened. When coal prices were liberalised again in 1992, coal production from local mines grew rapidly through the first half of the decade, demonstrating the effectiveness of pricing policy on production. By the late 1990s, however, coal demand weakened significantly leading to oversupply, resulting in central policies aimed at closing down small, inefficient, and illegal mines, in an effort to both reduce production and more closely regulate small mines in general.

Industry Structure

The coal industry structure is relatively fragmented and diverse since the propagation of local mines. Between large-scale modern facilities and small village operations, China's coal mining industry covers a broad range in terms of company size and ownership, mine size and type, levels of mechanization, and management sophistication.

While the petroleum industry is dominated by three key state-oriented enterprises, the top three coal enterprises represent less than 15 percent of China's coal production. Nevertheless, Shenhua Group, China's biggest coal enterprise, is also one of the biggest coal producers in the world with over 200 million tonnes yearly capacity. But for every Shenhua, there are thousands of local mining operations that together produce over one third of China's coal. In 2006, there were about 80,000 estimated total coal mines in China and average production was only about 30,000 tonnes.[u]

[u] *Wan Zhihong 2007*

State owned mines dominated the industry until the early 1980s when central policies opened coal resources to local investment and development during a time of shortage. Today, mines are categorised into key state-owned, state-owned, and local-owned mines, each representing 48 percent, 14 percent, and 37 percent of production, respectively, in 2005 **[52.1]**.[v]

[v] *China Databar 2006*

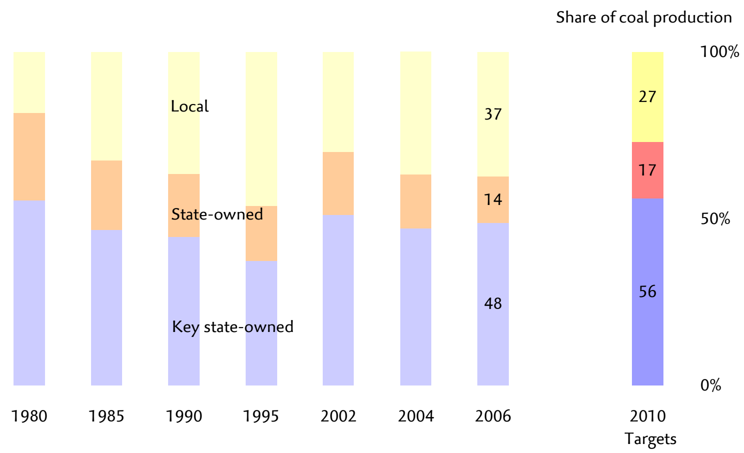
Ownership levels can determine some general characteristics. For example, key state-owned mines are modern corporations that generally operate large scale mines with high levels of mechanisation and management sophistication. Local-owned mines, on the other hand, are more diverse: some are modern operations but a larger portion are small mines that might use backwards technology and have low extraction efficiencies and poor safety records. For example, the average coal extraction efficiency in Shanxi province is about 40 percent, but some of its small local-owned mine have efficiencies as low as 10 to 20 percent.[w] Additionally, local-owned mines are notorious for a high rate of mining deaths. While producing about one-third of China's coal, local-owned mines are responsible for over two-thirds of China's mining accidents and deaths.[x] Local-owned mines average approximately 5.7 worker deaths per million tonnes of coal produced. In comparison, the ratio in Shandong (the province with the most advanced mining industry) is about 0.34 deaths per million tonnes, and the average ratio for key state-owned mines is about 0.93.[y] Small mining operations generally lack the resources to implement the necessary technology, training, and worker incentives to raise safety standards and practices.[z]

[w] *Cui et al. 2007*

[x] *4384 out of 5938 in 2005, or 74 percent; CCII 2005*

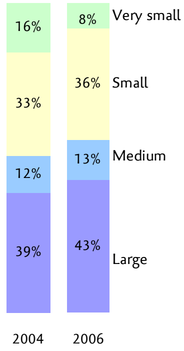
[y] *CCII 2005; Ratios are average over 2004 and 2005.*

[z] *For more information, see World Bank 2004.*



52.1 **Share of coal production by ownership structure (multiple years)**
Creedy et al. 2006

Indeed, many of the challenges facing China's coal industry can be traced to the poor capacity of small local mining operations. Small mines have been targeted for closure and reform since the late 1990s, and this continues today. The *Eleventh 5-year guidelines for coal industry development* called for further production cuts from small and local-owned mines. **[53.1]** shows the break up of coal production by mine size. Very small mines (those with annual capacities of 30,000 tonnes or less) are currently targeted for consolidation, and their share of production is already declining. For example, in Hunan province, small mines with production under 30,000 tonnes are merged with other mines so that combined production exceeds 60,000 tonnes. As a result, the number of mines has dropped from 2163 in 2006 to 1120 in 2007.[aa] Current targets mandate additional cuts in local-owned mine production, decreasing their share to 27 percent by 2010 **[52.1]**.



53.1 **Share of coal production by mine size (2004, 2006)**

China Coal industry Yearbook 2006-2007

Unlike previous closure mandates, however, the new policy emphasises mergers and acquisitions as an effective exit strategy for small firms that can leverage local support. One reason for this approach is the desire to support local economies, local government tax revenues, and jobs. In 2005, 4.28 million people were employed in the coal industry with an average monthly wage of CNY 1799.[bb] Although reform may change employment structures, these mines will continue to employ a number of local workers and support government incomes after reformation.

Once merged, however, mines must pass inspection to ensure they meet necessary standards before reopening, and this process has halted production in many small mines. The resources tied up in small mines are significant, however, and access to this coal is important to keep production levels in pace with growing demands. As recently as May 2008, central policymakers issued a statement addressing the need to quicken the pace for approving the reopening of small mines to help ensure sufficient coal supplies.[cc]

[aa] *Hunan Coal Bureau 2007*

[bb] *CCII 2005*

[cc] *NDRC 2008*

Market Consolidation

To address energy security concerns, China has historically directed significant political and financial attention to development of the coal industry. The *Tenth 5-year plan*, enacted during a period of oversupply, concentrated on shutting down small, illegal, and inefficient mines and restructuring state-own mines to increase their competitiveness. In contrast, the *Eleventh 5-year guidelines for coal industry development*, issued January 2007, focused on optimising industry structure through market consolidation. It also emphasised improved resource utilisation through better operational management, technological improvements, increased regulation, and higher efficiency.

A key component of the plan calls for a drastic market reorganisation in the upstream so as to build large coal conglomerates with the aim of improving production efficiencies, safety, and ease of regulation. As noted previously, large enterprises are encouraged to take over smaller operators and mines through mergers and acquisitions, with targets to decrease the share of local-owned mines to 27 percent by 2010. Also outlined by the coal development plan, by 2010, thirteen coal production bases are to be established in key coal-producing regions across fourteen provinces with a combined annual coal production of 2.24 billion tonnes, accounting for 86 percent of total production. Additionally, six to eight coal enterprises with annual capacities above 100 million tonnes and eight to ten enterprises with annual capacities above 50 million tonnes are to be established with a combined production exceeding half of China's total.

In step with efforts to modernise the industry, coal enterprises are also expected to use more advanced technology for exploration and production, increase mechanisation, and improve the recovery ratio above 40 percent. Additionally, measures will be taken to further improve mine safety and reduce the death rate to below 1.6 per million tonnes and improve environmental protection by requiring the setting aside of remediation bonds and treating wastewater.

China is relying heavily on the financial and management capacity of large coal enterprises to elevate the coal industry to modern status. These mining groups must not only rapidly expand production to meet surging demands but also manage market consolidations and eliminate the backward practices of small mines, all in a way that utilises resources efficiently, ensures miners' safety, and protects the environment.

Economics of Coal Production

The affordability of coal contributes to its popularity, but continued supply of cheap coal is not guaranteed. Extraction costs of coal are generally lower than that of petroleum or natural gas. Globally, coal energy can be "provided" for about USD 20 to 40 per tonne oil-equivalent, compared to USD 240 and USD 480 for oil and natural gas respectively.[dd] In China, the average production cost of coal in 2005 was about CNY 200 per tonne (real 2005 USD 48.8 per tonne oil-equivalent), a growth of 18.5 percent from 2004.[ee]

Coal production costs are expected to increase further in the near future following revision of existing tax rates and introduction of new measures including special fees or funds for environmental protection and optimisation. A number of new measures, first launched in Shanxi province in 2007, are expected to expand to more provinces in the near future, including the *Sustainable development fund*, *Mine restoration management fund*, and *Mine transformation development fund*. Existing taxes to be reformed include the *Coal resource tax*, *Compensation fee*, *Future development and maintenance fee*, and *Production safety fund*.[ff]

On the demand side, coal price is of great importance to China's industries and its rapid increase in recent years has presented challenges to enterprises for which coal is both an important fuel and feedstock. Coal accounts for over 95 percent of thermal power generation, 50 percent of industrial energy consumption, and 60 percent of chemical feedstock.[gg] In 2005, the average price of steam coal increased 31 percent to CNY 270.2 per tonne (real USD 65.95 per tonne oil-equivalent) Prices for power generation contracts also rose 31 percent to CNY 212.75 per tonne (real USD 51.93 per tonne oil-equivalent).[hh] And, the price has continued to increase in 2007 and 2008 driven by robust demand and supply bottlenecks. Power generators, for example, have been especially challenged by rising thermal coal prices. Though once beneficiaries of low contract prices under two-tiered pricing system and then government supported contract pricing, power companies now

[dd] *MIT 2007*

[ee] *CCII 2005*

[ff] *APERC 2007*

[gg] *MIT 2007*

[hh] *CCII 2005*

[ii] *See "Ongoing issues in power and refining" section of this report.*

[jj] *See "Energy pricing" section of this report.*

[kk] *Business Week 2008; In June 2008, NDRC released a suite of energy pricing adjustments including raising of electricity tariffs and temporarily capping coal price.*

negotiate coal purchases at near market prices while regulation of on-grid electricity tariffs continues, impacting industry profits.[ii] And though the central government has recognised this challenge to power generators, policy relief has been delayed on numerous occasions[jj] in part owing to a desire to tame high inflation rates. In fact, high thermal coal prices throughout 2008 invited some generators, awaiting price drops or government pricing intervention, to run down stockpiled coal.[kk]

ENERGY SECURITY AND COAL TRANSPORT

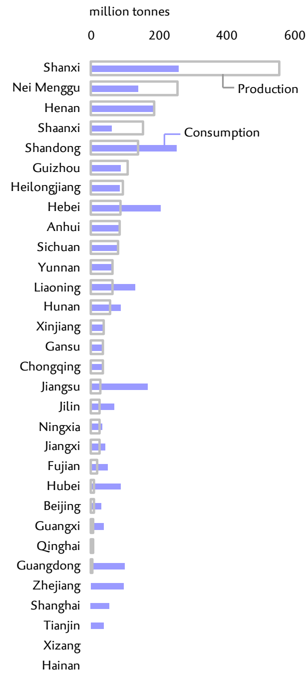
Utilisation of coal has contributed to Chinese energy self-sufficiency. While imports now supply approximately half of Chinese petroleum consumption, steadily rising coal production through the reform period has enabled China to both meet domestic demands and export coal as well. Although imports exceed exports for the first two quarters of 2007 for the first time in the reform period, China remained a net exporter on year's end.

Self-sufficiency, however, does not directly equate to energy security. Owing to uneven geographic distribution of coal resources, coal transport is a major issue facing continued coal supply security in China. China's largest coal reserves are located far inland, hundreds of kilometres from the coastal industrial centres where coal is most demanded. The majority of China's coal (61 percent) is produced in the three regions to the north and west (Xibei, Huabei, and Dongbei), while major centres of energy demand are spread through the more developed coastal regions to the south and east **[55.1]**.[ll] Security of coal supply relies on the efficient, reliable, and affordable transport of coal from where it is produced to where it is consumed. Moreover, addressing this challenge will become increasingly important with time as coal production shifts west towards the large but more distant reserves and resources of Xinjiang and Nei Menggu.

INTER-PROVINCIAL COAL MOVEMENT

The movement of coal between provinces has increased through the reform period, as has its share of total production as seen in [56.1, 2].[mm] This means that provinces are increasingly reliant on coal from other provinces and regions, particularly for those provinces in the southeast, and that this trend is likely to continue as more provinces deplete internal resources. For example, production in Shandong province, once a significant production centre, has already levelled off (peaking in 2003), and Shandong coal companies are moving operations and investments to more coal-rich provinces to the north and west.

Notably, Xinjiang, despite having the most coal resources, does not currently supply much coal to other provinces. In 2006, Xinjiang produced less than 2 percent of China's coal, nearly all (95 percent) to meet its own demand. It is currently uneconomical to transport Xinjiang-produced coal to supply the eastern provinces.[nn]



55.1 **Coal production and consumption by province (2006)**

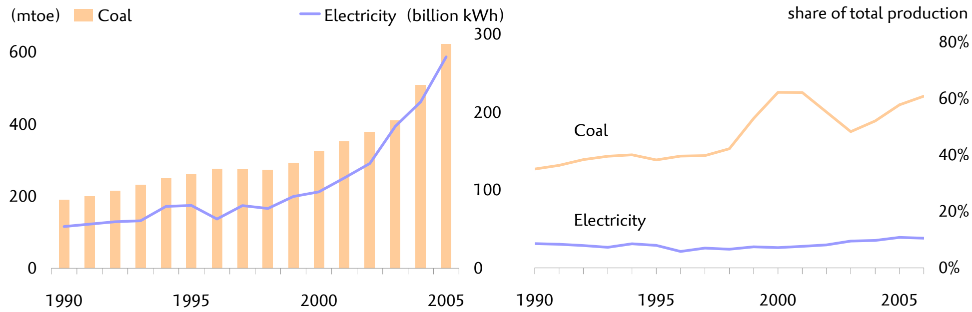
APERC 2008

Case of winter 2008

The unfortunate events of the 2008 winter snow storms exemplified the wide-reaching repercussions of disruptions to China's coal transport network and energy system. Fallen transmission lines led to widespread black-outs. And in other areas, when heavy snow impeded freight operations along major rail lines and roads, coal could not reach consumers in many areas and local stocks were drawn down or depleted. In some cases, even areas without direct grid damage lost power as generators ran out of coal. Seventeen provinces suffered blackouts.

55.2 **Disruptions in energy transport**

Liu Xiaoli 2008



56.1,2 **Intra-provincial movement of coal and electricity, amount and share of total production (1990-2006)**

APERC 2008

[ll] *China Databar 2006*

[mm] *Inter-provincial coal trade is calculated from "moving in from other provinces" field of China Energy Statistical Yearbooks.*

[nn] *As a reference, the distance between Urumqi, capital of Xinjiang, to Beijing is 3820 kilometres.*

[oo] *China Databar 2006; Coal Industry Yearbook (CCII 2005) states 1.066 billion tonnes.*

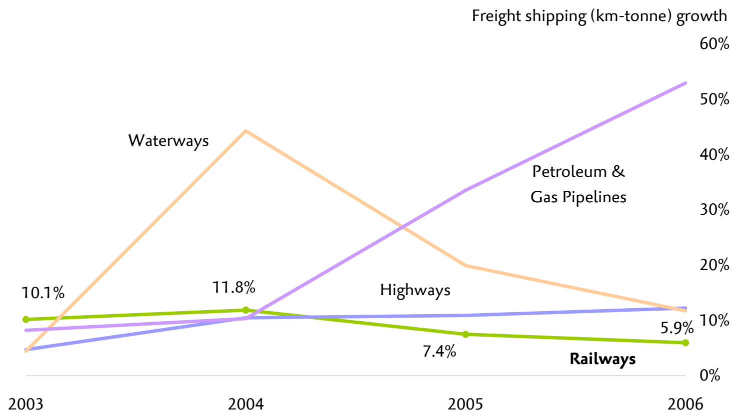
[pp] *Shaanxi DRC 2007*

[qq] *APERC Database 2008*

[rr] *Cui et al. 2006*

The majority of coal transported from production centres to demand centres across China is done by rail. In 2005, 1.29 billion tonnes of coal was transported by rail, 58.9 percent of the total transported coal tonnage.[oo]

In general, total Chinese rail freight transport (in terms of tonne-kilometres) has not been growing as fast as other freight traffic **[56.3]**, and rail transport bottlenecks are chronic. For example, rail transport in Shaanxi province in 2007 was estimated to satisfy only about 40 percent of demand.[pp] Total rail transport freight volume grew at an annualised 8.8 percent per year from 2002-2006. This is significantly lower than the growth in coal production (13 percent) and provincial movement (17 percent).[qq] Coal accounted for about half of the total rail freight tonnage in 2005 (47.9 percent of 2.69 billion tonnes), having climbed steadily from 41 percent in 2000.[rr]



56.3 **Freight shipping growth, by mode (2003-2006)**

APERC 2008, Industrial Map of China Energy 2006

Truck and Ship Transport

In recent years, as rail-based coal transport pushed up against capacity limits, further pressure was put on to highway freight transport to reinforce regional supply chains, though with variations from year to year. 529 million tonnes of coal was transported by truck in 2005, down from a high of 590 million tonnes in 2004. Transporting coal by truck uses more energy per tonne-kilometre than by rail or waterway, so such shipments are usually for shorter distances. Also, high petroleum product prices makes such transport relatively expensive.

About 371 millions tonnes of coal were shipped by waterway in 2005 both for export (72 million tonnes) and to coastal provinces in the south (300 million tonnes).[ss]

Transport Cost

Transport costs make up more than half of delivered costs for domestic coal in the southern coastal provinces.[tt] Each tonne of coal shipped from Datong in Shanxi Province to Guangzhou uses an estimated 18 litres of diesel.[uu] In energetic terms, just transporting the coal negates about 4 percent of its calorific value. Transporting the coal by rail alone (2600 kilometres) would use 4 percent more diesel. In such a situation, shipping by truck would use 13 times as much energy as by rail. Shipping coal from Australia (8000 kilometres by sea), on the other hand, uses an estimated 14 litres of diesel per tonne.[vv] In comparison, transporting coal from Urumqi, Xinjiang province to Qinghuangdao (4200 kilometres by rail) requires 30 litres of diesel and negates 6 percent of the coal's calorific value.

Cost of transporting coal is another concern. At CNY 6 per litre for diesel, the cost of fuel alone amounts to CNY 108 per tonne of coal shipped from Datong to Guangzhou.[ww] Under high crude oil and petroleum product prices, the economics of transporting coal will further limit where coal customers can afford to purchase coal.

IMPORT-EXPORT

The transport issue is also an important driver of recent coal import-export trends. Bottlenecks along the major coal rail routes have kept coal supply tight in many regions and have encouraged coastal provinces to import more coal. New coal policies further encourage coal imports while exports continue to be regulated by quotas issued from central agencies.

As seen from **[58.1]**, China's coal and coke net exports have been declining steadily since 2002, and the share of net export to total production has dropped even more dramatically. China, however, continues to be a large coal exporter, even though exports weakened in 2005 and 2007 due to tight coal supplies. Historically, even in times of tight supply, world coal and coke prices that exceeded Chinese domestic prices encouraged strong exports, including from state-oriented enterprises. Because of this, Chinese leaders set export quotas each year to help balance domestic supply and demand while protecting industry profitability. Currently, only four state-oriented enterprises have rights

A robust coal transport network is crucial to the security of coal supply in China. Within this network, rail is a key player because it is capable of moving over a billion tonnes of coal over long distances from coal producing regions in the west to inner provinces and coastal ports. Thus, both coal and rail industries will need to further develop and optimise rail infrastructure for coal transport. Yet, even rail lines cannot affordably transport coal from Xinjiang province to resource-poor coastal provinces. Into the future, Xinjiang coal reserves have the potential to provide cheap, reliable, and even environmentally sustainable domestic energy when combusted using appropriate technology. In response, government agencies and enterprises have in the past and now continue to mitigate coal transport demand by encouraging mine-mouth operations, transforming Xinjiang (or other regions') coal first into electricity, chemicals, and other energy intensive products for more efficient supply to the rest of China. Such an approach still requires significant infrastructure investments (in upgraded power grids, for example), but ultimately helps to manage energy disruption risk. Such activity will be important in ensuring not only today's coal distribution, but also tomorrow's resource accessibility.

57.1 **Transport demand management**

[ss] *Cui et al. 2006*

[tt] *Schneider et al. 2000; Also see "Energy Pricing" section of this report.*

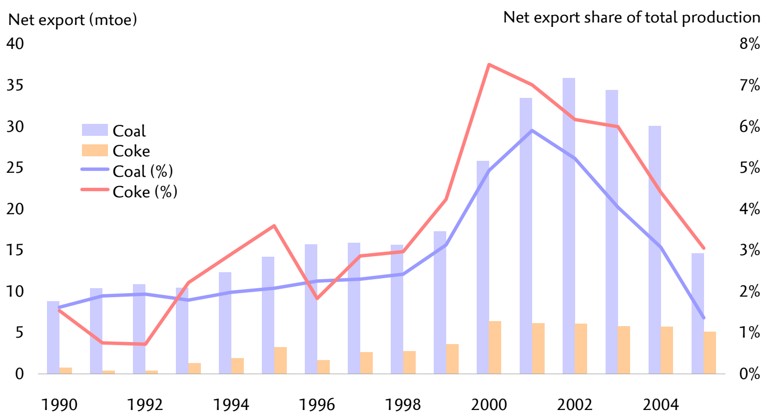
[uu] *Estimated using 650 kilometres by rail between Datong and Qinghuangdao, a major northeastern coal port, and 2650 kilometres by sea between Qinghuangdao to Guangzhou. Energy intensities of freight transport within China are based on Skeer and Wang 2007.*

[vv] *Estimated using the international shipping intensity of 1.7 tonne oil-equivalent per megatonne-kilometre from the Australia Logistics Council.*

[ww] *Equivalent to a fuel price of USD 0.73 per litre diesel and shipping costs of USD 13.14 per tonne.*

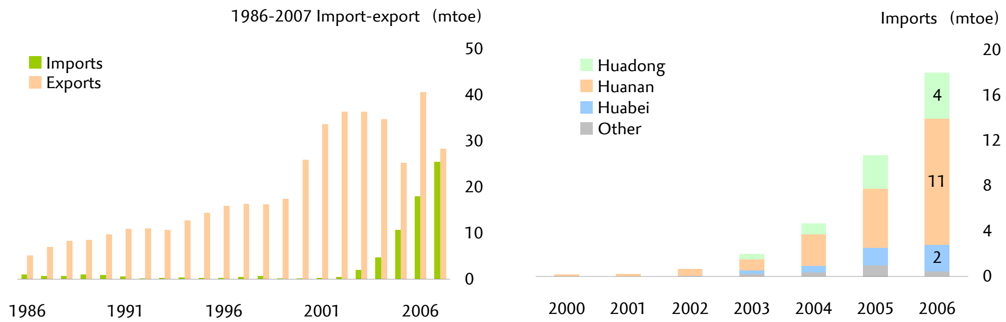
to export coal, with China Coal Energy Corporation exporting the largest share.

New central policies, however, are changing the import-export landscape. The coal export tax rebate policy was revised in 2006 in an effort to ease domestic coal supply shortages, lowering import tariffs while raising export tariffs. Additionally, government-guided contract pricing for thermal coal was disbanded starting in 2007. Since then, tight domestic coal supplies have driven up domestic prices and the gap between domestic and international prices has diminished. In the short term, this has weakened incentives to export, while encouraging more imports. In the longer term, however, such policies will likely help to further liberalise coal markets by bringing domestic prices in line with world prices, thus negating the need for export quotas while encouraging more efficient movement of coal within China.



58.1 Coal & coke net exports and net export share of total production (1990-2004)

APERC 2008



58.2,3 Coal import-export and imports by region (1986/2000-2006)

APERC 2008, Industrial Map of China Energy 2006

As coal exports remain high, declining net exports can really be explained by the rapid rise in coal imports **[58.2]**. The majority of imports are supplying the Huanan region, with Guangdong as the biggest consumer. Imports to the Huadong region are also increasing. This suggests coastal cities are finding it more comparatively economical to import coal purchased on the world market **[58.3]**. In general, nearly two-thirds of imports are of high calorific coal (anthracite and coking coals), while exports are primarily steam coal.[xx]

Imports will continue to benefit from the new tariffs and market pricing policies. The dismantling of government-guided thermal coal contracts will encourage more coal consumers to purchase their coal where it makes the most sense, as exemplified by Guangdong province.[yy] There, as in other parts of the Huanan region, coal demand is strong, geographic position makes domestic coal relatively expensive or at times unreliable, and the region's advanced economic development makes international imports relatively affordable. With increasing domestic prices, lower import taxes, and persistent transport bottlenecks, more and more coastal consumers are likely to turn to international coal shipped from Southeast Asia and Australia.

OPPORTUNITIES AND CHALLENGES

Despite aggressive pursuit of alternatives, China will continue to depend on coal for many years to come. China's electricity generation is heavily reliant on coal, and electricity demand growth continues to be strong through the near- to mid-term. The electricity sector is forecast to account for more than 85 percent of total incremental coal growth through 2030.[zz] And despite efforts to diversify into renewables, nuclear, hydro, and natural gas, the vast majority of new on-grid power generation capacity being built continues to use coal— albeit more efficiently— because it is economical, available, reliable, and fast to deploy. Moreover, coal demand growth for industry will mirror production growth in industry subsectors, despite improved industrial efficiencies.

The coal industry will expand production in the short term to meet rising demands. But looking to the future, other measures must be considered to maintain a robust coal sector, especially as the most desirable coals are depleted and production shifts to more remote resources and lower quality coals. Meeting mounting coal demands while securing adequate supplies for tomorrow will likely require adjustments in the way coal is extracted, transported, and used. A secure coal future will mean not only balancing supply and demand, but doing so in a way that mitigates transport bottlenecks, conserves resources and protects the environment. Improving efficiencies of extraction and utilisation, alongside other measures, can help.

OPTIMIZING RESOURCES

Reserve lifetime can be extended by improving extraction efficiencies and developing technologies suitable for cleanly extracting and combusting high-ash and high-sulphur coals. Efficiency improvements in coal extraction, as currently pursued, have great

Reduced coke export quotas have caused a slow and steady decline of coke exports since 2000. In the future, however, higher export tariffs may instead assume prominence. High international prices for coke incentivised Chinese producers to expand production and exports through the late 1990s, but government agencies regulated exports through quotas due to concerns over pollution and coal shortages. But while 2008 export quotas for coke are a modest drop from 2007, the export tariff increased to 25 percent from 15 percent in January 2008 in a move to cut exports of energy intensive products. Over time, a tariff- rather than quota-based system will likely contribute to more efficient allocation in the domestic economy—where coke demand remains strong— if policymakers remained convinced of the effectiveness of this more market-based tool.

59.1 **Coke exports: from quotas to tariffs**

[xx] *Sagawa and Koizumi 2007*

[yy] *personal communication 2007*

[zz] *APERC 2007*

potential to extend the life of China's coal resources. The average extraction rate in China is only one half that of developed economies, and levels of mechanisation are low. Although China's coal resources are sometimes difficult to mine due to the inherent geology, low extraction efficiencies have persisted in large part due to disaggregated ownership structures but also due to high barriers for foreign investment and reliance on domestic mining technologies.[aaa] *Eleventh 5-year guidelines* target extraction efficiency improvement of 10 percentage points to 40 percent, as is developing modern mining equipment and efficient open-pit mines.[bbb] The biggest challenge to achieving these higher extraction rates is upgrade of backwards mining technology. New policies specifically target small, local mines, but successfully reformation of these mines will require significant financial and time investments, especially on the part of large coal enterprises (through M&A). It is estimated CNY 91 to 116 billion (USD 11 to 14 billion) in investments are needed to replace small mines with large capacity mines.[ccc] Under the current approach to reform, however, coal enterprises themselves are tasked with significant ultimatums that may be difficult to achieve even for well-performing firms, including pressures to further increase coal production capacity, achievement of central consolidation goals, and preparation for higher fees and taxes in the future. Moreover, tight overall coal supplies make it more difficult to justify mine closures, even inefficient ones.

[aaa] *World Bank 2004; Johnson 1999*

[bbb] *Improving extraction efficiencies through coal mine modernisation and mechanisation has been a stated target of numerous 5-year plans through the reform period.*

[ccc] *World Bank 2004*

Aside from improving extraction rates, China can benefit from the clean and efficient use of lower quality coals and mining wastes. Sub-bituminous and lignite coals are estimated to make up about 45 percent of total reserves, while high ash and high sulphur coals are often difficult to utilise. Into the future, however, these resources may prove more economical than geographically remote resources and, with clean combustion operations, can mitigate strains on coal transport, resource depletion, and the environment. Already, fast-spreading flue gas desulphurisation (FDG) equipment ensures power plants can meet emissions standards while burning medium-sulphur coals. Co-development of coal methane is also being vigorously pursued, while development of combined fluidised bed (CFB), integrated gasification combined cycle (IGCC), and other clean coal combustion technologies is making progress.[ddd]

[ddd] *Such advance coal combustion technologies are often discussed in the context of reducing carbon dioxide emissions. Their designs, however, also make it easier to combust low-quality coals while minimising local air pollution impacts. This is a significant driver of their development and deployment in China today.*

Efficient coal transport

Future coal supply stability will rely heavily on affordable and adequate coal transport. Only a handful of provinces are still self-sufficient in coal, while many are experiencing diminishing reserves. As this trend continues, coal will increasingly be supplied by the major coal producing regions, namely in Shanxi, Shaanxi and Nei Menggu. To deliver this coal, China will require significant investments for upgrading and expanding rail transport infrastructure. Resolving rail transport bottlenecks can also ease pressures to transport coal by truck, a costly and energetically wasteful method. The cost of coal transport, however, is perhaps a greater challenge. In light of rising petroleum prices and insufficient transportation capacity, the cost of transporting coal has been increasing faster than pithead prices for coal consumers in China's coastal provinces.[eee]

Besides increasing rail freight capacity to meet coal transport demands, China can improve supply chains through measures that reduce transport needs, for example, by transporting electricity or coal-intensive products rather than raw coal. Mine-mouth industries are already prevalent in China, and efforts to send electricity from resource rich western areas to coastal provinces are well underway. These enterprises can streamline coal supply chains by reducing the distance between extraction and use, and they have the potential to replace transport of large quantities of coal in the future. Current limitations on the development of mine-mouth coal industries and power generation include constrained water resources in coal-rich areas and over-burdened power transmission networks. Major grid companies, however, are stepping up efforts to expand transmission and distribution capacity, with particular emphasis on the long-distance high and ultra-high voltage lines of the West-to-East Power Transfer Project.[fff] Domestic development of transmission and distribution technologies is also emphasised in the *Eleventh 5-year guidelines*. Increased foreign collaboration, however, may further quicken the speed of development and deployment. Coal washing at the mine-mouth also has the potential to reduce transport demands by improving the energy-density of the transported coal product, but broader implementation of this seldom-adopted practice in China has faced repeated barriers despite coal industry modernisation.[ggg]

Participation in international coal markets can also help reduce burdens on domestic coal transport. Already, coastal provinces are finding it more economical to import coal from Southeast Asia and Australia, while markets are favourable for continued coal export from China's northern ports to neighbouring economies. By further integrating with international markets, China can improve the efficiency of coal movements across China and the APEC region. International and regional coal markets, however, are facing significant challenges with high price fluctuations and supply bottlenecks from inadequate infrastructure, natural disasters, and growing global demands. Increasing coordination between importing and exporting economies is necessary to help ease future imbalances and ensure greater supply security of coal internationally.

SECURING SUPPLY BY ADDRESSING DEMAND

As clearly recognised and communicated by the central government at the outset if the reform period, the greatest potential for achieving adequate coal supplies and increased energy security lies in slimming demand. Whether through increased boiler efficiencies and other new technologies, energy use management, or economic restructuring, reducing demand growth will ease the pressure to build more production capacity and energy transport infrastructure while also conserving resources for future use and prolonging China's domestic energy supply.

[eee] *CBN 2008*

[fff] *See "Ongoing issues in power and refining" section of this report.*

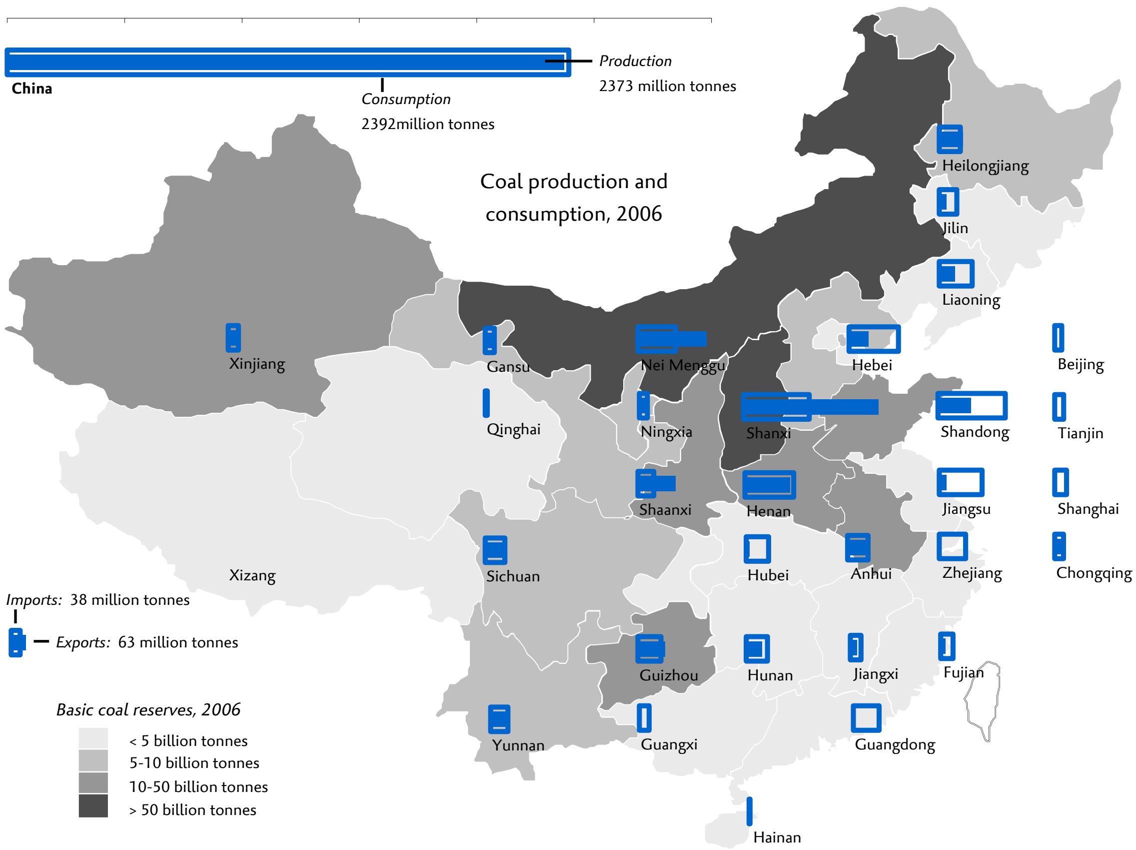
[ggg] *Historically, low prices for coal and lack of emphasis on coal quality in pricing structures have been identified as reasons for the slow adoption of coal processing in China. See Johnson 1999.*

The potential for coal use efficiency improvements in China is great and progress in this area is certain, though the scope and speed of efficiencies improvements rests on the will of industry leaders. For example, for iron and steel, China accounts for about one-third of global production but captures about half of the global potential for energy optimisation if using today's best available technologies, with the greatest potential coming from boiler improvements.[hhh] Other subsectors, such as cement, have similar potentials. China's power industry also has potential for significant efficiency gains.

[hhh] *IEA 2008*

Overall efficiency improved steadily over the reform period and China seeks to meet efficiency levels of developed economies. The speed of efficiency improvement, however, will likely depend on local incentives for efficiency investment and improvement. The greatest challenges to resource efficiency thus far has been the persistence of small operations, usually at the local level, which rely on inexpensive, outdated technologies. Acknowledging this, central policies to improve industry efficiencies and reduce pollution have, in the past, focused on closing down small or inefficient coal mines, power generators, paper mills, steel mills, cement plants (sometimes referred to as the "Five Smalls"), among others.

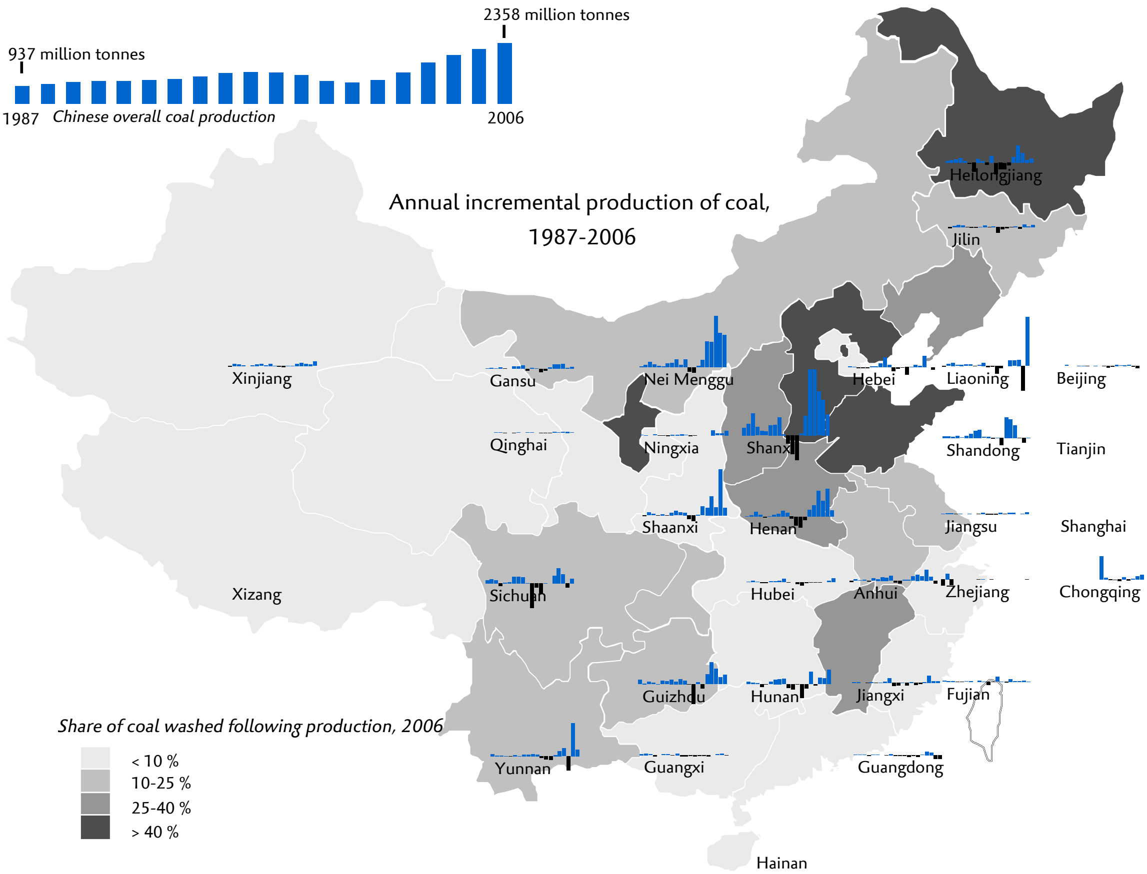
The greatest uncertainty for China's coal future rests on conservation— China's ability to mitigate demand through economic restructuring and lifestyle choices. Though the *Eleventh 5-year guidelines* adopted ambitious targets to reduce energy intensity and aimed to shift economic development away from energy intensive industries, the policy tools available to orchestrate economic development are far more limited than those aiming to improve efficiency. Example actions included the restricting of financing and investment by public actors as well as the limiting of construction permits for energy intensive industry, while at the same time promoting development in service industries. Some of the more powerful tools, however, such as energy pricing, have proven challenging to implement due to other socio-economic considerations. Key to sustained reforms, therefore, will be the determination of China's central leadership.



63.1 **Current coal production and consumption**

APERC 2008

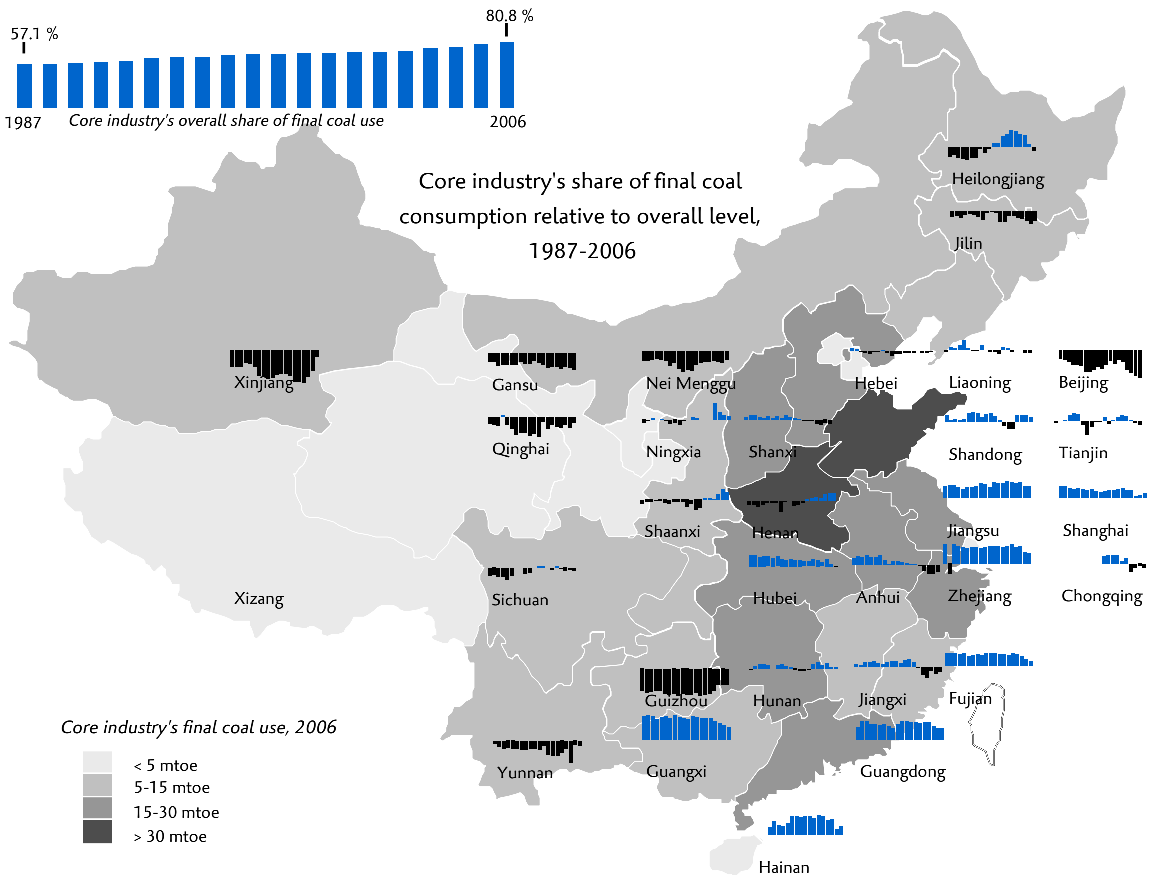
- Overall, total coal consumption in China exceeded production by about 19 million tonnes. [note: this reported economy-level figure differs from a regionally-aggregated figure]
- Regionally, total coal production in 2006 was centred in Shanxi, Nei Menggu, and surrounding areas. Outside of this coal-rich production region, most provinces consume more coal than they produce, especially along the southeastern coast where production is minimal, while southwestern provinces are generally self-sufficient.
- Basic coal reserves are largest in Nei Menggu and Shanxi, which together account for about half of China's 334 billion tonnes of basic reserves.



64.1 **Coal production**

APERC 2008

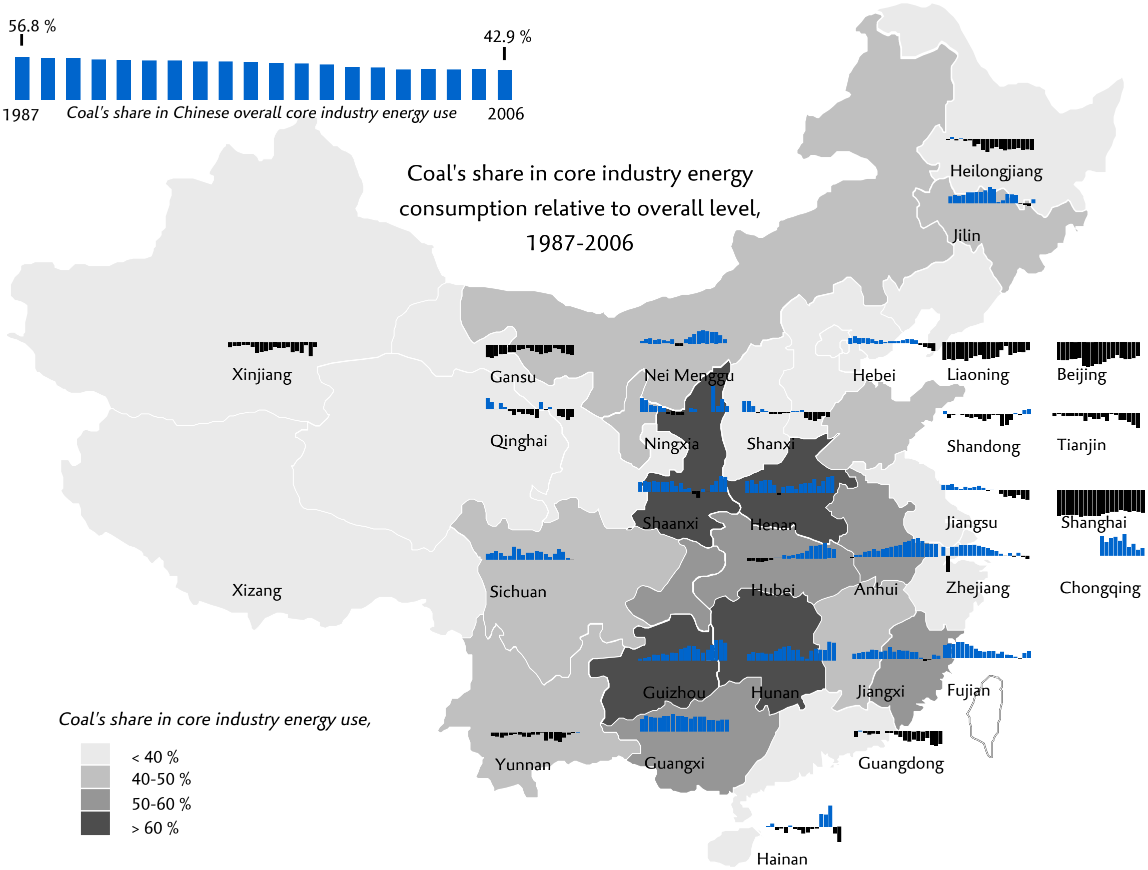
- Overall, total coal production rose from 937 million tonnes in 1987 to 2358 million tonnes in 2006. Production initially peaked at 1394 million tonnes in 1996 and declined to 1047 million tonnes in 2000 before more than doubling in the five years following.
- Regionally, annual incremental coal production was particularly strong after 2000 in Nei Menggu and Shanxi, and still strong but to a lesser extent in Shaanxi , Henan, Shandong, and Guizhou. In the late 1980s and early 1990s, Shanxi had the most incremental production growth, but, like many other producing regions, stagnated or declined in production levels in the late 1990s.
- The share of coal washed following production exceeds 40 percent in Heilongjiang, Ningxia, Hebei, and Shandong. Regions with the most rapid recent growth in production do not necessarily have the highest share of coal washed following production.



65.1 **Core industry coal use**

APERC 2008

- Overall, core industry's final coal use rose gradually from 57.1 percent of all final coal use in 1987 to 80.8 percent in 2006. [note: final coal consumption does not include coal use in the transformation sector, for example, power generation]
- Regionally, core industry consumed a smaller share on final coal use in the western provinces than it did in the eastern provinces. Central regions were approximately in line with the overall economy average, and trends were rather stable over time.
- The total amount of final coal used in core industry is highest in Henan and Shandong.



66.1 **Coal's use in core industry**

APERC 2008

- Overall, the share from final consumption of coal for core industry energy needs gradually declined, from 1987 when final consumption of coal represented 56.8 percent of energy use down to 42.9 percent in 2006. [note: though the share declined, total consumption nevertheless rose significantly over this period]
- Regional variation in the share taken by coal for core industry energy needs is broad. Though trends in the change in share are not strong, Guizhou, Hunan, Hubei, and Anhui have gradually increased their share from coal, while Guangdong, Fujian, Zhejiang, and Jiangsu have gradually decreased their share from coal.
- Coal's share in core industry energy use is highest in Guizhou, Hunan, Shaanxi, and Henan.

Overseas Upstream Investment and Petroleum Supply Security

Global investment in the energy resource sector is booming. The prospect for continued growth in energy demand, along with sustained high energy prices, have pushed the world's oil and gas companies to increase upstream oil and gas investment efforts. This phenomenon is particularly pronounced among state-oriented oil enterprises as the enhancement of energy security has become a broadly-shared policy agenda. China's three major state-oriented oil enterprises (CNPC, Sinopec, and CNOOC) are often considered to be global leaders in such efforts because of their visibility in a recent surge to acquire overseas upstream investment stakes and because of the sheer size of future needs to meet Chinese petroleum demand.

To fill the gap between a growing appetite for oil that exceeds production from domestic oil fields, Chinese state-oriented oil enterprises have increased efforts to acquire overseas upstream stakes of oil and natural gas. In fact, such efforts are often supported by the central government through tax breaks and lower interest payments, leading some to describe such activities as threats to both oil majors and other national oil corporations. For example, the 2005 failed attempt by CNOOC to acquire Unocal illustrated ambivalence in the US economy over Chinese oil firms' overseas investment activities and their repercussions.

Such alarmist arguments about Chinese state-oriented oil enterprises are often exaggerated as they fail to put China's activities in the context of broader global trends. In other words, to assess their progress in an objective manner, China's overseas investment activities should be compared with those of other economies. In order to draw policy implications for the enhancement of energy security in China and identify areas for cooperation in the APEC region, this section considers such comparative positions of Chinese state-oriented enterprises by addressing the following questions:

- What are the drivers and enabling factors for upstream investment activities by the Chinese state-oriented oil enterprises?
- Are Chinese state-oriented oil enterprises really buying up world resources?
- How much oil has been produced and imported from such overseas equity fields?
- How does equity oil enhance China's oil supply security?

DRIVERS AND ENABLING FACTORS FOR OVERSEAS UPSTREAM INVESTMENT

"Self-sufficiency" was once an implicit goal of China's energy supply development. From the late 1970s, however, there was a gradual yet clear shift away from self sufficiency.[a] Instead, the "rational use of energy" has been more strongly emphasised since China started oil imports in the late 1970s, and, in particular, since becoming a net oil importer of crude oil and oil products in 1993.

[a] *Godement 2007*

Oil production from northeast China's centrepiece Daqing oil field, developed since the 1950s, peaked at 1.1 million barrels per day in 1997, and now declines at an annual rate of 4 percent, a decline somewhat stabilised by significant upgrade in extraction technology.[b] And though oil production growth from other younger fields such as Shangli and Bohai Bay compensate for declines in Daqing, the rate of increase in domestic consumption far exceeds that of domestic production.

[b] *Economist 2008*

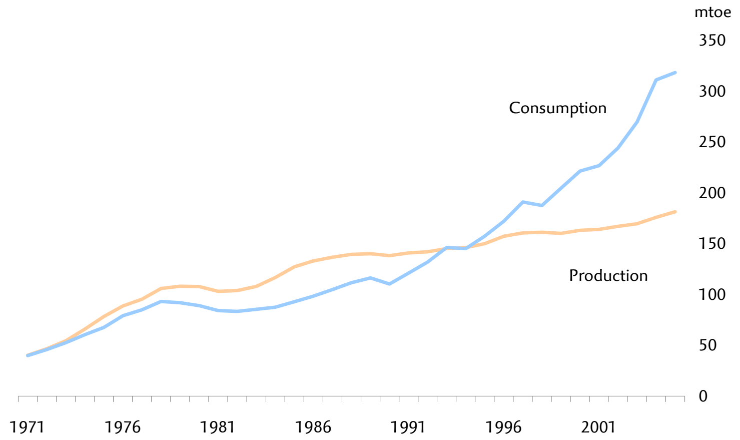
The widening gap between production and consumption is currently filled by imports as illustrated in **[68.1]**. In 2007, China imported 4.1 million barrels per day of oil, and ranked third in the world after USA and Japan.[c] As a result, net import dependency of crude oil and oil products combined rose from 22 percent in 2002 to 47 percent in 2007.

[c] *BP 2008*

Nevertheless, China's state-oriented oil enterprises are intensifying their exploration of domestic fields. In fact, the annual number of wells drilled domestically increased from 10,007 in 2002 to 16,360 in 2007.[d] Recent efforts to explore and find oil are concentrated on onshore fields in the western provinces of Xinjiang, Sichuan, Gansu, and Nei Menggu, as well as on the offshore fields in the Bohai Bay, Pearl River Delta, and South China Sea.[e] However the exploration and development of domestic oil fields is unlikely to meet the expected rise in domestic oil demand. According to the *APEC outlook 2006*, China's net oil import ratio is expected to reach 70 percent in 2030 from 49 percent in 2007, which provides a rational for Chinese oil firms to increase invest in overseas oil exploration.

[d] *EDMC 2008*

[e] *EIA 2008*



68.1 **Oil production and consumption (1971-2005)**

APERC 2008

In the *Tenth 5-year plan* (2001-2005), the central government underscored the importance of overseas upstream investment.[f] The Plan encouraged oil firms to be involved in international operations as part of a "Go Out" strategy. The strategy was and still is intended not only to acquire upstream stakes, but also to facilitate wider adoption of Chinese technology, equipment, materials, and labour in the overseas market. The Plan also stated that central government approval for many upstream projects would be phased out in order to allow firms to make decisions and take risks.

[f] *Overseas upstream investment was encouraged as part of the Ninth 5-year plan, but was given particular emphasis in the Tenth 5-year plan as the oil demand-supply gap continued to grow.*

To facilitate the "Go Out" strategy, the Chinese central government supports oil firms' active involvement in overseas upstream investment in various ways. For example, in November 2004, the National Development and Reform Commission (NDRC) and the Export-Import Bank of China (China Exim Bank) jointly announced that the bank would earmark a portion of FDI budget for key overseas investment projects including natural resource development at an interest rate discount of at least 2 percent.[g] This contrasted with the Central Bank's decision to raise domestic interest rates to 6.2 percent in October 2004.

[g] *Downs 2007*

Besides the provision of lower interest rates, there are a number of other complimentary preferential treatments for overseas investment projects[h], including but not limited to:

[h] *Overseas investment projects eligible for such preferential treatments include (1) upstream development, (2) infrastructure development to promote the adoption of Chinese technologies, (3) innovative research and development projects, and (4) international M&As.*

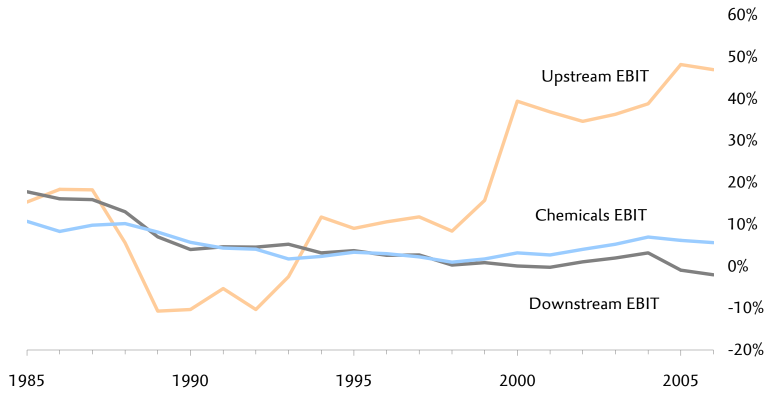
- No collateral is required for firms to purchase export machineries, technologies, parts, and raw materials.
- No income tax is levied for the initial five years of project operation.
- The timing for settling the expenses for machineries, technologies, parts, and raw materials can be flexibly extended if conditions are appropriate.
- Central government provides insurance for machineries, technologies, parts, and raw materials for projects.
- Central government enhances the support system for Chinese firms by increasing the number of overseas branch offices for state-oriented enterprises.[i]

[i] *Guo Sizhi 2007*

In addition, commercial motivations have driven Chinese firms to go abroad to acquire upstream stakes. As a result of maintained low final product domestic price and rising crude oil price, the financial performance of China's downstream sector, including petrochemical production, has been performing poorly.

[70.1] shows historical trends in the average profit margins of upstream, downstream, and chemical operations for Chinese oil enterprises from 1985 to 2006. It is evident that the gap between profit margins from upstream business and that from downstream and chemicals has been widening, particularly after 2002, the year when international crude oil prices started rising sharply.

Due to the sustained high oil price and regulated final product prices, it is natural for Chinese oil firms to find overseas upstream investment opportunities to offset downstream sluggishness.



70.1 **China's oil and gas profit margin (1985-2006)**

Houser 2007

OVERVIEW OF UPSTREAM ACTIVITIES IN OVERSEAS PROJECTS

Chinese overseas investment in oil and gas has been primarily conducted by three giant oil corporations. These are CNPC, Sinopec, and CNOOC. As **[70.2]** shows, CNPC is the largest investor in overseas projects, operating 70 projects in 25 economies. This is followed by Sinopec, operating 36 projects in 14 economies. CNOOC operates 18 projects in 5 economies.

	NUMBER OF OVERSEAS PROJECTS	DESTINATION OF UPSTREAM INVESTMENT	EQUITY OIL (MILLION BARREL/DAY)	EQUITY GAS (100 MILLION M3/YEAR)
CNPC	70	Africa, Middle East, Central Asia and Latin America; Total 25 economies	0.60	38
Sinopec	36	Asia, North America and Middle East; Total 14 economies	0.14	--
CNOOC	18	Asia and Oceania; Total 5 economies	0.02	13.5

70.2 **An overview of China's overseas investment**

Guo Sizhi 2007, APERC 2008

China began overseas oil field development in Thailand in 1993. This coincided with China having become a net importer of crude oil and oil products. This first foray was made by CNPC for a of 95.67 percent interest purchase of the Banya Blok in Thailand. Then, in 1994, CNPC purchased licenses to develop oil fields in Peru and Canada.

The first two large oil projects, which continue to produce more than 100,000 barrels per day, were acquired in 1996 and 1997. One was Sudan's Unity/Hegling oil field. In 1996, CNPC purchased a 40 percent share to develop Block 1/2/4 of Unity/Hegling oil field from Arakis, a Canadian oil company. With Arakis, CNPC established a consortium, the Greater Nile Petroleum Operating Company (GNPOC), in the same year. Currently, as a result of changes in ownership, shares of GNPOC are now owned by CNPC (40 percent), Petronas of Malaysia (30 percent), ONGC of India (5 percent), and SUDAPET of Sudan (5 percent).[j] Since first exports in 1999, the production from Unity/Hegling oil field has been stable at about 150,000 barrels per day of crude oil.

[j] *JOGMEC 2007*

In 1997, CNPC purchased another large oil field from Kazakhstan, now a main exporter of equity oil to China. CNPC purchased a 60.3 percent stake in AktobeMunaiGas, the fourth-largest oil company in Kazakhstan. CNPC now holds an 85.42 percent share of the company following purchase of an additional 25.12 percent of total share-holdings in 2003. With a production license and exploration contract for the Zhanazhol, Kenkiyak Oversalt, and Kenkiyak Subsalt oilfields, CNPC has invested more than USD 1.5 billion to reconstruct ageing oil and gas processing plants and build new facilities for processing, transporting, and storing oil and gas. As a result, crude oil production more than doubled from 53,000 barrels per day in 1997 to 118,000 barrels per day in 2006.[k]

[k] *CNPC 2008*

Since announcing its "Go Out" strategy in the Tenth 5-Year Plan in 2001, China's overseas oil and gas investment has accelerated sharply.[l] Most of the projects are small in scale, producing well below 100,000 barrels per day.[m] However, three project areas have greater potential to play important roles in meeting China's future oil demand: the Yadavaran oil field of Iran, Angola, and acquisition of PetroKazakhstan.

[l] *The "Go Out" strategy was first discussed in 1996, but reiterated as part of the Tenth 5-year plan.*

[m] *Eurasia Group 2006*

Yadavaran oil/ LNG

In 2004, National Iranian Oil Corporation (NIOC) and Sinopec signed a preliminary MOU on the development of Yadavaran oil field. The field is expected to produce 300,000 barrels per day of crude oil, half of which will go to Sinopec.[n] The preliminary MOU was reached on condition that Sinopec develops the oil field with a commitment to buy 10 million tonnes of LNG for 25 years.[o] The two sides, however, have not reached final terms, and the prospects remain unclear. For example, NIOC has subsequently announced an MOU with India for ONGC to acquire a 20 percent stake of the project.

[n] *Eurasia Group 2006*

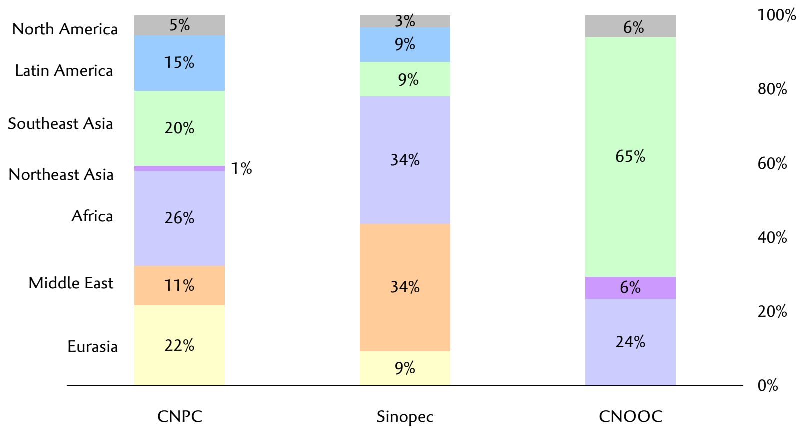
[o] *IHT 2007*

Angola

In 2005, Sinopec purchased a 37.5 percent stake in the Greater Plutonio field project in offshore Angola. In 2007, the field produced 240,000 barrels per day of crude oil, with Sinopec's proportional take at 90,000 barrels per day.

PetroKazakhstan

CNPC purchased PetroKazakhstan in 2005 with a 100 percent equity share. Under the agreement with the Kazakh Ministry of Energy and Mineral Resources, in 2006 CNPC transferred 33 percent of total shares in PetroKazakhstan to KazMunaiGaz, retaining a 67 percent stake in the company. In 2006, PetroKazakhstan produced 217,000 barrels per day of crude oil.



72.1 **An overview of China's overseas oil & gas project by region and by company**

Lieberthal and Herberg 2006, APERC 2008

REGIONAL DISTRIBUTION OF INVESTMENT ACTIVITIES

Regional distribution for upstream projects differs widely by company **[72.1]**. CNPC's current investments are in Africa (26 percent), Eurasia (22 percent), and Southeast Asia (20 percent). Sinopec's upstream stakes are concentrated in the Middle East (34 percent) and Africa (34 percent). By contrast, CNOOC's upstream activities are largely held in Southeast Asia (65 percent), followed by Africa (24 percent).

The wide disparity in regional concentration of the three major state-oriented oil enterprises may underscore their different business practices. CNPC has the strongest connection with the central government, and goes overseas to invest in oil/gas field projects that are underpinned by government commitment to the host economies. For example, assisted by the central government through aid packaged, CNPC has been able to explore oil and gas projects in relative politically high-risk regions such as in Sudan. By contrast, CNOOC's business practice is more similar to that of the international oil corporations; illustrating this, the company has focused on Southeast Asia as political risk there is relatively low. Sinopec's business practice is somewhere between CNPC and CNOOC.

The difference in regional focus among these three companies may also explain their lack of coordination. Instead of actively cooperating to acquire overseas stakes, they compete for a particular niche given financial and technological conditions.

OIL AND GAS FDI

Overseas oil and gas investment by China increased sharply from 2001. According to the 2005 *Statistical bulletin of china's outward foreign direct investment*, outward cumulative FDI on mining, quarrying, and petroleum in the three years 2003-2005 reached real (2005) USD 5 billion, accounting for 24 percent of China's total outward FDI.[P] Although the sub-sectoral breakdown is not available in the *Statistical bulletin*, the bulk of this figure is estimated to consist of investment in oil and gas.

[P] *China's outward FDI investment figure prior to 2003 is not available.*

INDUSTRY	FDI 2003-2005 (BILLIONS USD (2005))	SHARE OF TOTAL FDI
Business services	6.014	29%
Mining, quarrying & petroleum	**5.002**	**24%**
Manufacturing	3.720	18%
Wholesale & retailing	3.469	17%
Transportation & storage	1.524	7%
Agriculture, forestry, husbandry & fishery	0.495	2%

73.1 **China's outward FDI (2003-2005)**

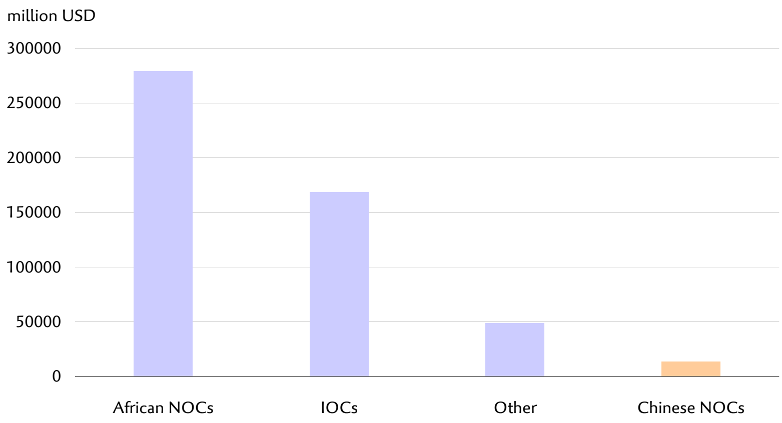
Ministry of Commerce of China 2003-2005, APERC 2008

Similarly, total global investment in oil and gas exploration and production increased sharply in recent years driven mainly by the sustained high oil price, from real USD 177 billion in 2004, to USD 214 billion in 2005, and further to USD 259 billion in 2006 – a sustained annualised growth of 25 percent.

Despite its recent surge in overseas oil and gas investment, China's presence in the global upstream business is still small. Applying published data by the Ministry of Commerce, China's outward investment in oil and gas accounts for only a small share, 1 percent, of total global oil and gas upstream investment in 2004 and 2005.

China's small presence in the global upstream oil and gas business reflects three distinguishing characteristics of its overseas investment strategies. Firstly, China's state-oriented oil enterprises often take minority shares in project consortiums, where majority shares are taken up by NOCs or IOCs. Secondly, China's state-oriented enterprises generally purchase shares in small-scale projects which produce less than 100,000 barrels per day for their equity share. Thirdly, a number of China's overseas oil and gas investments are risk projects, which are offered at lower prices.

By region, China's investment in Africa accounts for the largest share at 27 percent, followed by Southeast Asia at 22 percent. In Africa, China's oil firms invest in oil and gas projects in such economies as Algeria, Angola, Niger, Nigeria, Sudan, Gabon, Congo, and Cote d'Ivoire with nearly 40 deals being closed. Yet despite such involvement by Chinese oil firms, their investment accounts for only a small share of total investment by both NOCs and IOCs in Africa. According to a figure by Wood Mackenzie from 2006, the share from China's state-oriented oil enterprises in total upstream investment in Africa accounts for only 2.6 percent. In African oil E&D projects, the largest share taken by African NOCs, followed by IOCs. In fact, spurred by the rising oil price, African NOCs are intensifying efforts to invest in other African economies.



74.1 **Upstream oil & gas investment in Africa (2003-2005)**

Wood Mackenzie 2006, APERC 2008

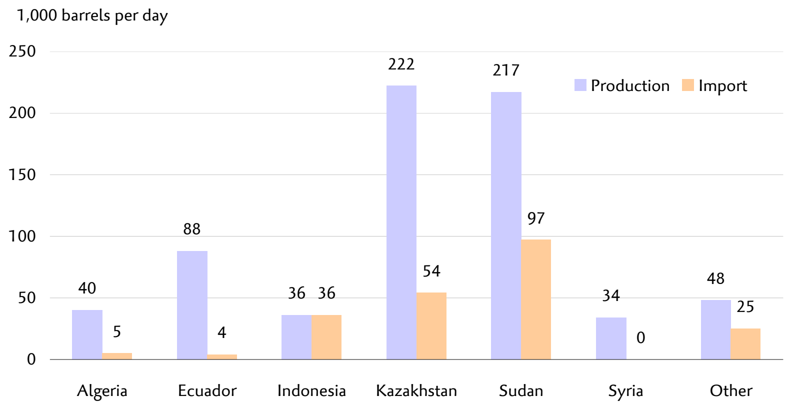
EVALUATION OF ENHANCEMENT OF OIL SUPPLY SECURITY

Given the drivers and trends in China's overseas upstream investment activities described above, it worth considering the actual impact of such investments on China's oil supply security.

[75.1] shows the amount of oil produced and imported in 2006 from the six economies in which Chinese upstream stakes are concentrated (Algeria, Ecuador, Indonesia, Kazakhstan, Sudan, and Syria) as well as other areas from which production and import are either at the early stage of development or produce limited amounts presently. In 2006, China imported a total of 221,000 barrels per day from fields in which it holds upstream stakes, representing only 33 percent of total 685,000 barrels per day equity oil produced. Kazakhstan and Sudan are the biggest oil producers among the China's equity holdings, both of which produced more than 200,000 barrels per day of crude oil in 2006. However the exported amounts from Kazakhstan and Sudan to China were less than half that production amount at 54,000 barrels per day and 97,000 barrels per day respectively.

It is interesting to note that nearly 70 percent of crude oil produced from these equity fields is sold to the international market where higher bids are offered. This is in fact stipulated in the *Tenth 5-Year plan* in order to strengthen oil firms' financial performance. In addition, some crude oil produced from equity fields is sold to the international market due to a lack of appropriate refining spec.[q]

[q] *Rosen and Houser 2007*



75.1 **China's equity oil: Production and import (2006)**

Downs 2007, APERC 2008

Aside from securing oil from overseas upstream equity production, there are a number of other factors that can contribute to the enhancement of oil supply security. These may include (1) increase in domestic production, (2) shift away from oil dependence, and (3) securing oil supply from politically stable economies. Moreover, it is valuable to understand China's oil supply security status through comparison to other major oil importing economies in APEC.

To do so, the index below has been created to compare the relative position of oil supply security in China, Japan, Korea, and USA with respect to these four factors. This index is called the Oil Supply Security Index (OSSI). A higher OSSI value means higher oil supply security among the economies compared.

China and USA represent the similar OSSI levels at 42 and 41 respectively, while Japan and Korea represent almost the same level of OSSI at 27 and 26.

China's higher OSSI value reflects its higher self-sufficiency ratio and a higher independence from oil ratio (or lower dependence on oil) compared with the other economies.[r] The contribution of the equity oil ratio to the final OSSI is relatively small compared with the aforementioned two factors. However it should be noted that China's equity oil ratio is comparable in level to that of Japan and Korea. Despite China's relatively short history in pursuing overseas upstream investment activities, results have now neared the efforts of other economies.

Factors included in the OSSI indicator

▪ *Equity oil ratio* represents the equity oil import amount divided by total crude oil imports. For the US case, instead of the equity oil import amount, the total crude oil produced from the equity field is applied because of data unavailability.

▪ *Self-sufficiency ratio* is calculated as the ratio of domestic crude oil production to total oil consumption.

▪ *Independence from oil ratio* is calculated as the ratio of energy consumption, excluding oil, to total primary energy consumption. A higher value in this ratio means less dependence on oil for an economy.

▪ *Political stability* of crude oil import sources is calculated using the World Bank's Governance Indicator as a basis. Out of the six dimensions of the Governance Indicator, political stability index of oil exporters is weighted by the amount of crude oil export.

75.2 **OSSI indicator**

r *Although domestic crude oil production from the main fields is maturing, efforts to find new sources from offshore and western region contribute to enhanced oil supply security. Also, the economy's dependence on oil is the lowest among the economies presented since economic activities are heavily reliant on coal in the dominant power generation and industrial sectors. However, the economy's continued motorisation may change this oil supply position in the future.*

It is worth noting that China's political stability index for crude oil import sources represents the lowest level among economies presented here. This is because of a higher dependence on politically unstable economies such as in Africa, suggesting that to ensure stable oil supply, China may need to bear external costs outside project implementation.

The US's higher OSSI level, compared with Japan and Korea, reflects a higher equity oil ratio and higher self-sufficiency ratio. The relatively low OSSI levels for Japan and Korea result from the need to import almost all their consumed oil.

ECONOMY	EQUITY OIL RATIO	SELF-SUFFICIENCY RATIO	INDEPENDENCE FROM OIL RATIO	POLITICAL STABILITY OF CRUDE OIL IMPORT SOURCES	OIL SUPPLY SECURITY INDEX
CHINA	6.5%	53%	80%	29%	42
JAPAN	9.4%	1%	56%	44%	27
KOREA	4.0%	1%	54%	45%	26
USA	38.2%	33%	60%	32%	41

76.1 **Oil supply security: China, Japan, Korea, and USA**

APERC 2008; A higher OSSI value indicates higher relative oil supply security.

IMPLICATIONS

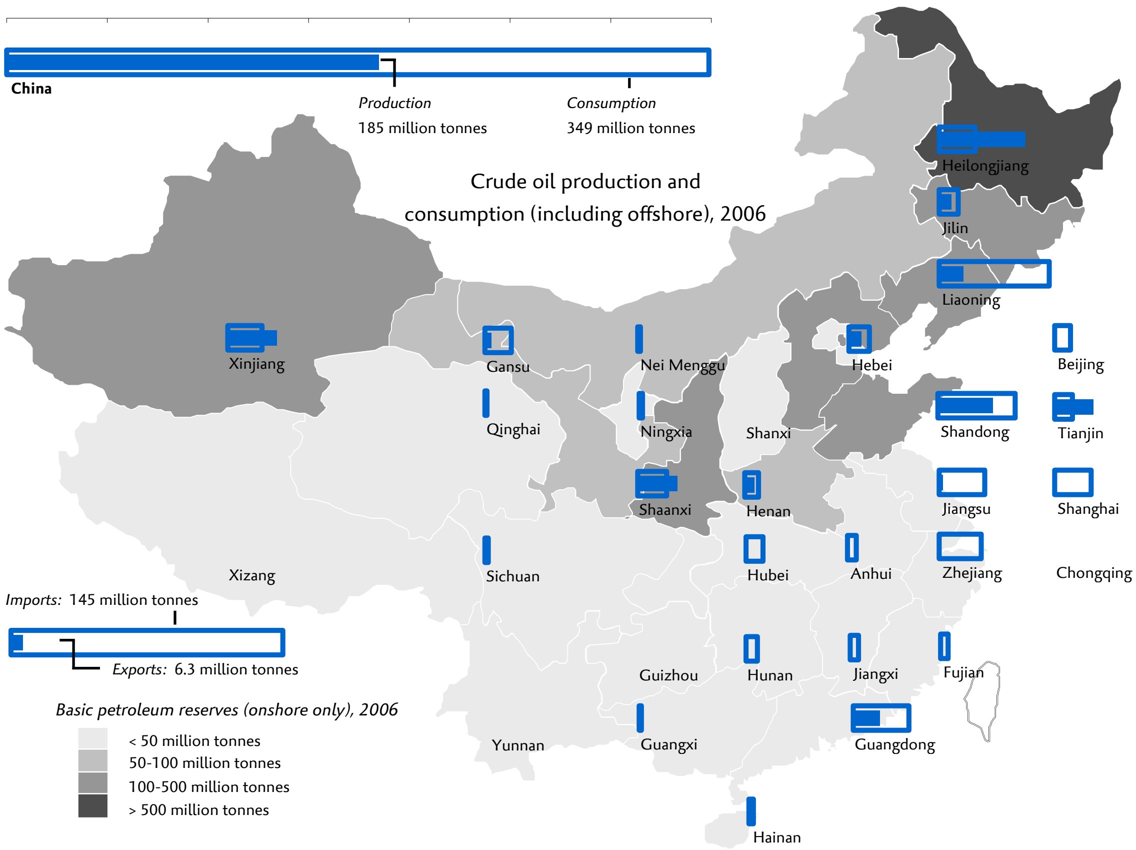
Despite alarmist arguments that China is buying up the world's oil stakes, the Chinese state-oriented oil enterprises' involvement in overseas upstream project actually represents a small share. The overseas upstream investment by Chinese oil firms account for only 1 percent of the global upstream investment in 2004 and 2005. Certainly, China's overseas investment activities have been rising since 2001; however, they often purchase small fields, or become a small part of an international consortium of which majority stakes are taken by host NOCs or IOCs.

Although China's involvement in overseas upstream business is small in size, and has a short history, it is true that China is successfully securing oil from overseas investment projects. In 2007, the share of equity oil to total crude oil imported accounted for 6.5 percent, compared with Japan at 9.4 percent, and Korea at 4 percent. Commercial motivations to be involved in overseas projects are high as state-oriented oil enterprises could potentially cover weak profits from downstream and chemical segments.

It is worth noting that China's overseas investment has helped increase the world's crude oil production. For example, crude oil production from Kazakhstan more than doubled as a result of CNPC's technology assistance and efforts to develop oil supply infrastructure. In fact, most of the CNPC's overseas equity investment is accompanied by a package of technology assistance, which helps to expand the global crude oil production amount.

Yet caution may be needed regarding the relatively high political risk in economies from which China is importing crude oil. China may need to bear extra costs in order to ensure stable oil supply from such politically turbulent regions.

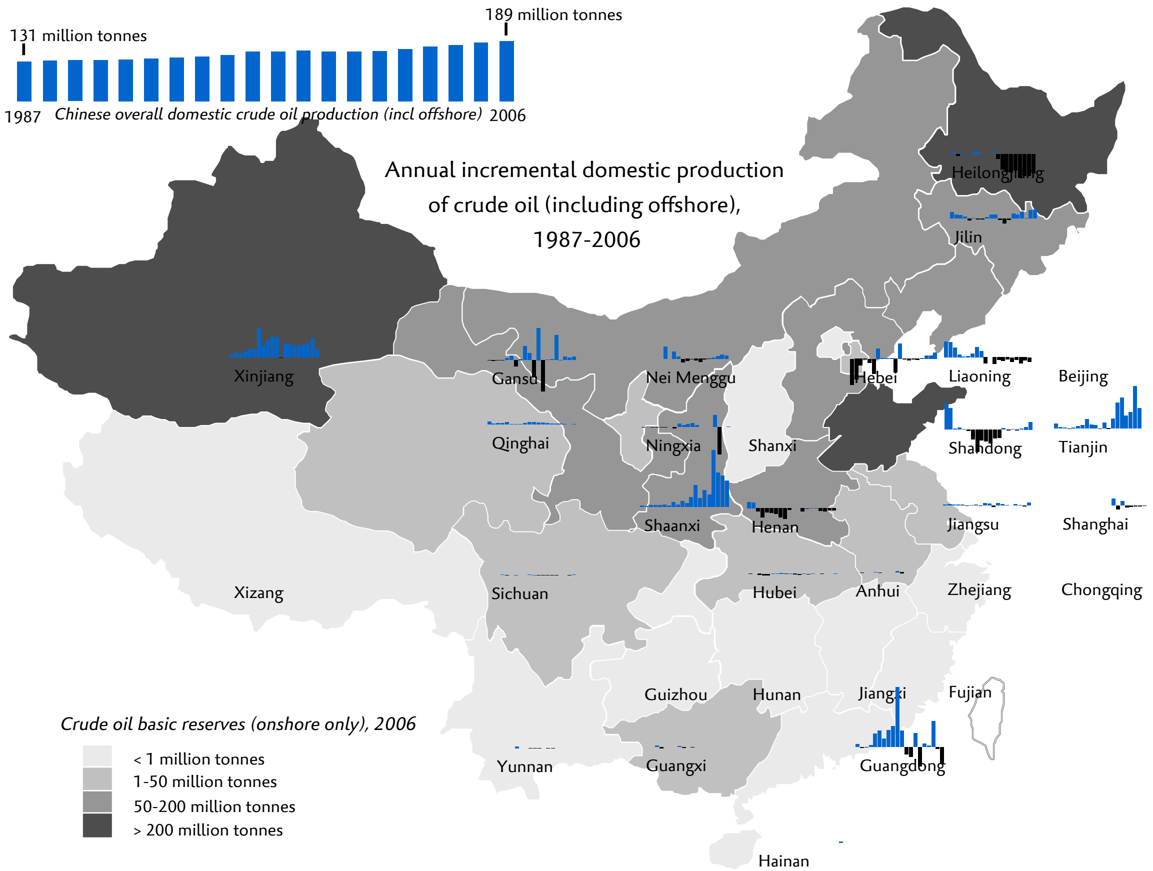
In the future, cooperation among China's oil firms with those of other APEC economies has the potential for win-win situations. China's investment may spur growth in host economies, while consortium partners might enjoy expanded market opportunities in China. Ultimately the concerted efforts among economies and firms within APEC should lead to greater oil supply security for both China and other APEC economies.



78.1 **Current crude oil production and consumption**

APERC 2008

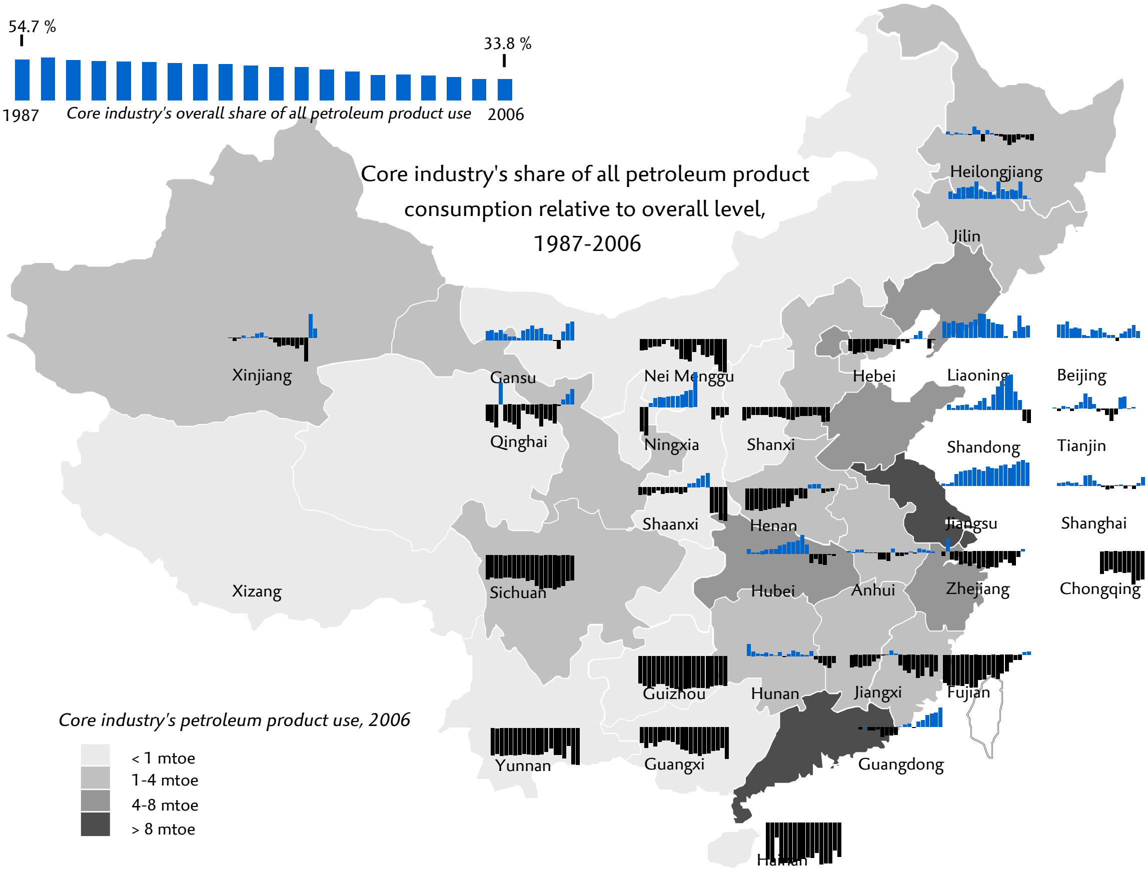
- Overall, domestic crude oil consumption in 2006 exceeded production by about 164 million tonnes; domestic production met about 53 percent of crude consumption. [note: this reported economy-level figure differs somewhat from a regionally-aggregated figure]
- Regionally, crude oil production is highest in Heilongjiang, Shandong, and Xinjiang. Consumption is dictated largely by the location of oil refineries, and is high, for example, in Liaoning and Shandong.
- Basic petroleum reserves are highest in Heilongjiang, but extend across other parts of northern China west to Xinjiang.



79.1 **Crude oil production**

APERC 2008

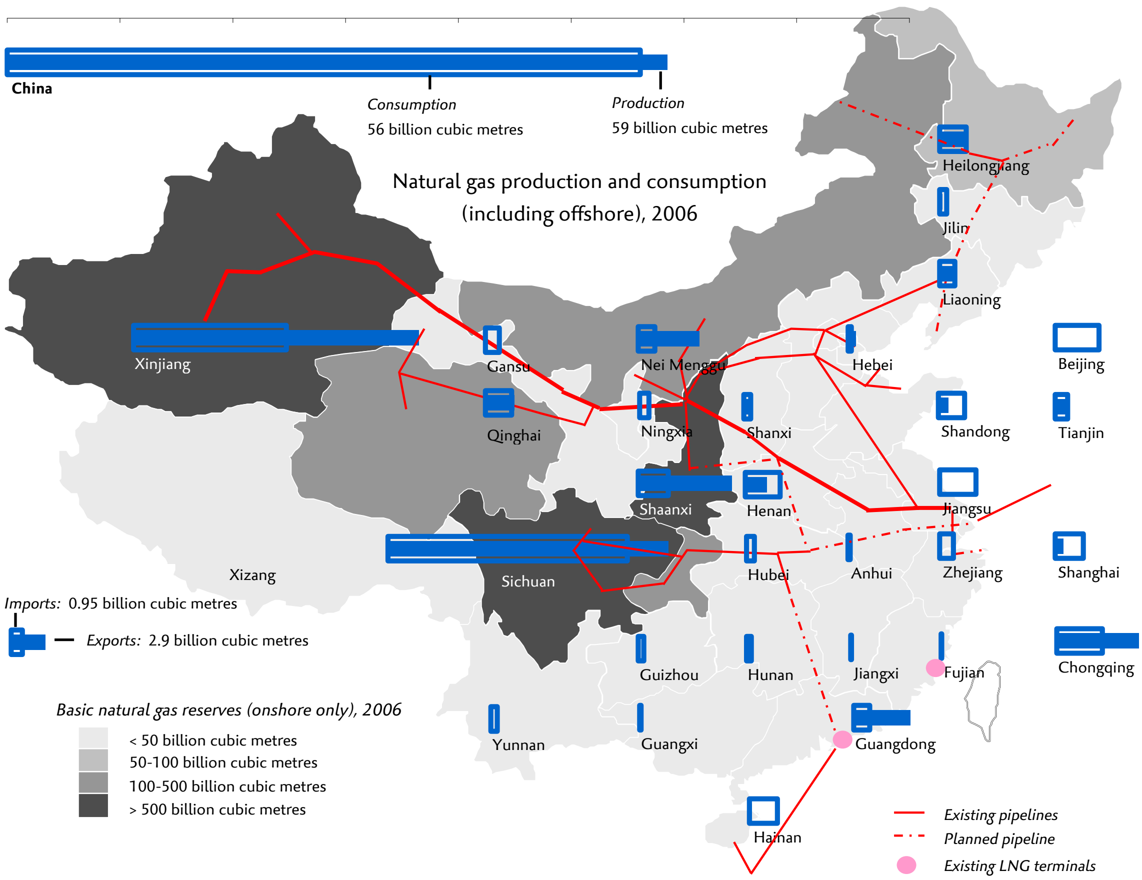
- Overall domestic crude oil production in China rose gradually from 131 million tonnes in 1987 to 189 million tonnes in 2006, having continued its previous rise following a levelling off in the late 1990s.
- Regionally, new incremental production in Xinjiang, Shaanxi, and (offshore) Tianjin have offset steady declines in earlier-developed areas such as Heilongjiang since the late 1990s.
- Onshore crude oil basic reserves are most extensive in Xinjiang, Heilongjiang, and Shandong, whereas reserves in the south are limited.



80.1 **Core industry petroleum product use**

APERC 2008

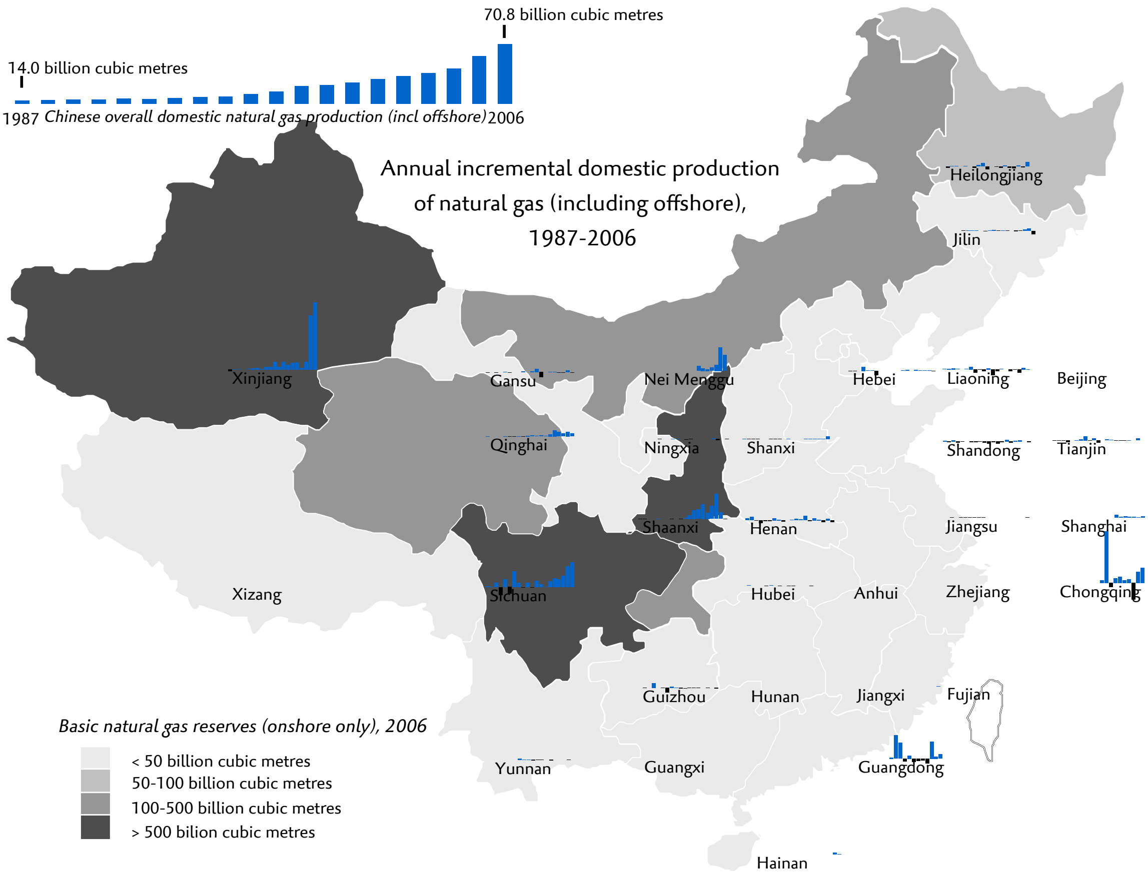
- Overall, core industry's share of petroleum product use declined gradually from 54.6 percent of total consumption in 1987 to 33.8 percent in 2006.
- Regionally, core industry's share of petroleum product consumption was consistently relatively low in the southwest while is was relatively higher in the eastern coastal provinces north of Shanghai.
- The total amount of petroleum products used in core industry is highest in Guangdong, Shanghai, and Jiangsu, though Guangdong's consumption equals that of the other two regions combined.



81.1 **Current natural gas production and consumption**

APERC 2008

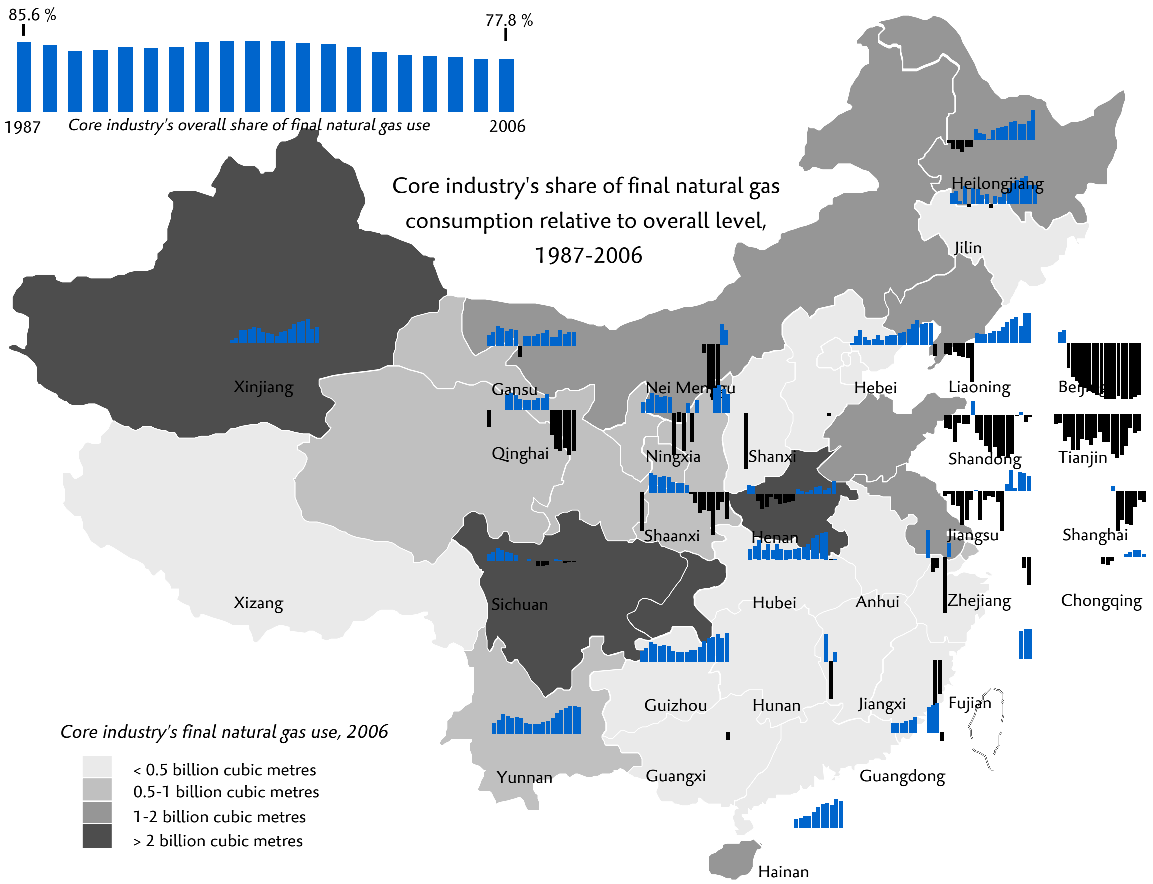
- Overall, natural gas production (including offshore production) exceeded consumption by about 3 billion cubic metres in 2006. [note: this reported economy-level figure differs somewhat from a regionally-aggregated figure]
- Regionally, natural gas production is highest in Xinjiang, followed closely by Sichuan. These two provinces also have the highest consumption of natural gas (for non-residential use). Chongqing, Shaanxi, and Nei Menggu also have significant annual production, as does offshore production attributed to Guangdong. Eastern consuming provinces including Beijing, Jiangsu, and Zhejiang rely almost entirely on gas moving in from outside areas.
- A major pipeline runs from Xinjiang to Shanghai, and a number of other pipelines and supporting spurs are planned or in construction to broaden the existing network and connect producing regions in the west to growing consumption centres in the east. Two liquefied natural gas receiving terminals are in operation as of 2008 and many more are planned or in construction.
- Major basic natural gas reserves are in Xinjiang, Sichuan, and Shaanxi.



82.1 **Natural gas production**

APERC 2008

- Overall, following a period of slow growth in the late 1980s, domestic natural gas production rose with gradual acceleration from 14.0 billion cubic metres in 1987 to 70.8 billion cubic metres in 2006, with particularly rapid growth in the last few years.
- Regionally, annual incremental natural gas production was clustered in both time and space. After about 2000, incremental growth was strong in Sichuan, Chongqing, Shaanxi, and Nei Menggu, while Xinjiang saw huge gains in 2005 and 2006 with the completion of natural gas pipeline projects. Most provinces outside of these mentioned here had very little growth in production, and production declines anywhere were quite rare.
- Basic onshore natural gas reserves are currently largest in Xinjiang, Sichuan, and Shaanxi provinces, each exceeding 500 billion cubic metres.



83.1 **Core industry natural gas use**

APERC 2008

- Overall, core industry's share of total final consumption of natural gas declined from 85.6 percent in 1987 to 77.8 percent in 2006, following a gradual rise through the mid 1990s.
- Regionally, the total amount of final natural gas consumption in core industry was smaller than for other fuels such as coal, so trends are somewhat lumpy as a few major consumers may be responsible for a significant share of natural gas consumption in one province. In cities such as Beijing, Tianjin, and Shanghai where natural gas is more broadly used in residential/commercial and transportation applications, core industry consumes a relatively smaller share than in other areas.
- In provinces including Yunnan, Guizhou, Hubei, and Jilin, core industry generally consumed almost all natural gas until very recently.
- The total amount of natural gas used in core industry is highest in or nearby production centres including Xinjiang, Sichuan, Chongqing, and Henan, each province exceeding 2 billion cubic metres annually.

ONGOING ISSUES IN POWER AND REFINING

A wealthier China's growing demand for more and higher quality energy alongside massive industrial investment is driving unprecedented investment in the transformation sector. Chinese power generation capacity, already the world's second-largest installed base, grew by an annualised 15.1 percent per year from 2002 to 2007, while petroleum refining capacity, also now the world's second-largest, grew quickly as well at 6.5 percent. Alongside such rapid demand and capacity expansion, these two sectors are challenged to ensure the secure supply of fuels such as electricity or diesel under both normal conditions and *force majeure*. Specifically, the power sector now seeks to reconcile historically uneven investment throughout the midstream to improve overall system performance. And both power and refining sectors hope to harmonise asymmetric price liberalisation across the energy supply chain, though their abilities to do so differ. The near-term measures taken by energy enterprises and government planners to address these challenges will have long-term effects on ongoing structural reforms in the transformation sector.

POWER

The power sector is paramount to China's energy security. It is critical not only for residential and commercial sectors, but for industrial and even transportation sectors too. From 2002 to 2007, a modernising China added an approximate average of 70 gigawatts of new generation capacity each year, with final electricity consumption heavily skewed towards industry, which represented approximately 74 percent of final consumption, followed by 11 percent for residential and an estimated 3 percent for the commercial sector (with a further 11 percent to other uses). Apart from the pace of expansion itself, the power sector today faces two major challenges: 1) in recent years, too much investment has gone toward new generation capacity and too little toward delivery infrastructure both in terms of coal supply and power transmission, threatening the security of power supply, and; 2) rising upstream market prices, particularly for coal (which fuels 79 percent of Chinese power production), have gone unmet by downstream government-guided on-grid electricity tariffs, squeezing generator margins on both sides. Both factors are exasperated considering the unique geographical conditions of China's power sector, in which energy resources from the western part of the economy must be transferred to demand centres in the east.

Overview of Power Generation Infrastructure

Electricity generation in China is heavily reliant on thermal power, almost all of it from coal, with a total installed thermal capacity of about 484 gigawatts. The central government encourages construction of efficient and advanced technology coal-fired units, such as supercritical or ultra-supercritical pulverised coal combustion power units over 300 megawatts in size. As of end of 2006, there were 635 individual 300 megawatt or above thermal power generating units with a combined installed capacity of 244 gigawatts, accounting for half of total thermal installed capacity. Increasing the size and efficiency of thermal power generation units has been an ongoing challenge. At the start of the *Eighth 5-year plan* in 1991, the central government set out to close small coal-fired and oil-fired units that used excessive energy or produced heavy pollution, but the results were not significant. In 2007, as part of the *Eleventh 5-yearguidelines*, the government announced a new plan to shut down all power generation facilities under 50 megawatts in size by 2010, accounting for a combined capacity of 15 gigawatts. Currently, and for the mid-term, natural gas will take only a marginal role for power generation in China as it is used primarily for city gas in residential and commercial sectors, as fuel for fleet vehicles such as taxis or buses, or for distributed combined heat and power (CHP) and combined cooling, heating, and power (CCHP) systems. For power, natural gas is only permitted to meet peak-load demand in those areas with concentrated power demand, such as coastal urban areas.

Hydropower, which holds the second largest share of power generation, has a long history of development in China, with installed capacity increasing from 0.163 gigawatss in 1949 to 128.6 gigawatts in 2006. [Zhou Fengqi and Wang Qingyi 2001] China still has a huge hydropower potential of 400 gigawatts and its exploitation potential ranks the first in the world. The largest hydropower facility in the world, the Three Gorges Project on Yangtze River, began generation in 2003. The total capacity for the project will be around 22.4 gigawatts and is expected to be fully operated by 2011. The second largest hydropower project in China, the Xiluodou hydropower station located in Xiluodu Gorge between Yongshan County in Yunnan and Leibo County in Sichuan, began construction in 2005. This hydropower station, which will reach a total installed capacity of 12.6 gigawatts, will be completed in 2015 and is one of four major hydropower stations planned under the China's West-to-East Power Transmission Project along the Jinsha and upper Yangtze Rivers. The second hydropower station under this project, the Xiangjiaba hydropower station, began construction in 2006. Located on the lower reaches of the Jinsha River, this station will have a capacity of 6 gigawatts (estimated annual output of 3 terawatt hours) and will be the third-largest hydropower station in China upon completion. The other two stations, 12.5 gigawatt Baihetan and 7.4 gigawatt Wudongde, will be located on the lower reaches of the Jinsha River and are now in planning. By 2017, the four hydropower stations will have a total installed capacity of 38.5 gigawatts, nearly double the generating capacity of the Three Gorges Project.

The history of nuclear power development in China is relatively short and slow compared to hydropower. The central government first considered development in 1974, but the first two nuclear power plants at Daya Bay in Guangdong and Qinshan in Fujian did not begin construction until the mid-1980s and commercial operation did not commence until 1994. By 2007, the total installed capacity of nuclear power was 8.6 gigawatts with a further six nuclear units of combined capacity of 5.6 gigawatts under construction. [WANO 2008]

Though its current installed capacity is still small relative to other generation, new and renewable power generation has developed rapidly in the past few years, especially wind power. By the end of 2006, China had more than 91 wind farms, with a total capacity of 2.6 gigawatts, a substantial growth from 0.399 gigawatts in 2002. Moreover, newly installed wind power capacity in 2007 alone was 3.4 gigawatts (including both on and off-grid capacity), bringing the total installed capacity to over 6 gigawatts. China is now the fifth largest wind power procedure in the world, after Germany, the US, Spain, and India. As the current installed wind power capacity has already exceeded the development target given in the *Eleventh 5-year guidelines*, the central government in April 2008 revised the target from 5 gigawatts to 10 gigawatts by 2010. This wind power growth is accompanied by the central government's encouragement for solar power, tidal power, and bio-energies.

Through the reform period, the Chinese power sector has passed through multiple stages, with reform ongoing today.[a]

- Pre reform: vertically integrated, state-owned, single body for generation and transmission/distribution
- 1985- 1996: additional generation investment and ownership by local and provincial governments along with limited business involvement (domestic and foreign); transmission/distribution centrally controlled
- 1997-2002: ~45 percent of capacity and 90 percent transmission/distribution (former Ministry of Power assets) controlled by newly-formed State Power Corporation; third party investment in generation continues under the 1996 Electric Power Law's concept of "reasonable return"
- 2002-current: State Power Corporation disintegrated with its generation and transmission assets separated and distributed among newly-formed SOEs; regulatory oversight by NDRC (sets tariffs) and State Electricity Regulatory Commission
- ongoing: SOE generation companies increasing market share, SOE grid companies face further reform

As a result of reforms, the power generation sector today has relatively diverse ownership, though most of it remains closely linked to the state. The five state-oriented generation companies formed in 2002[b] along with the two licensed nuclear power operators[c] account for approximately 40 percent of installed capacity, while provincial and local state-oriented generation companies account for a further 40 percent. Domestic and international IPPs combined control the rest.

Grid ownership remains more centralised, with control limited to two state-oriented enterprises, each with regional monopolies on transmission and distribution. The larger, State Grid Corporation, owns and manages grid operations across 26 provinces/regions, including 5 regional (multi-province) grid companies, and is affiliated with 24 provincial electric power companies and a number of affiliated research or construction entities. Its counterpart, China Southern Grid Corporation, is responsible for 5 provinces/regions, including Guangdong, which has the largest provincial power grid in China. Distribution occurs through coordination with provincial or other local companies by either of the two grid companies.

Coal industry ownership is diverse, and small players play a key role. State-owned mines dominated the industry until the early 1980s, when local investment was encouraged to increase total production. Today, the industry has both very small local producers and very large international-level enterprises, though, as an indicator of the size of the industry, the top three coal miners in China account for only 15 percent of total production. In 2005, key state-owned mines represented 48 percent of production, state-owned mines 14 percent, and local-owned mines 37 percent.[d]

[a] *Xu and Chen 2006; Jacobelli 2007*

[b] *Huaneng, Datong, Huadian, Guodian and China Power Investment Corporation.*

[c] *China National Nuclear Corporation and China Guangdong Nuclear Power Group, though a new state-oriented group, China Power Investment Corporation, was licensed as well in 2007.*

[d] *See "China's Story of Coal" section of this report for further information about this and other coal-industry issues.*

[e] *One method used to incentivise such investment in this period was to se on-grid prices based on repayment of capital.*

[f] *Chun Chun Ni 2005*

Through the 1990s IPPs faced a large market with high risks (including technology, operational, regulatory, and commercial risks) but with the prospect for high returns. This drew considerable attention into the sector, particularly after various institutional barriers were lowered in the mid 1990s, but low conversion rates meant that operational generation capacity involving FDI was limited—for example, only 24 plants with a combined capacity of 4.9 gigawatts by June 1998 (less than 2 percent of the total) [Blackman and Wu 1998]. Over time, though technology and operational risks fell considerably, the pace of improvement in regulatory and commercial risks, alongside declining margins, drove IPP investors (in particular, foreign investors) to exit the Chinese market, accelerating around 2002. Unlike the early years of private investment, when foreign IPPs were valued for their capital, technology, management expertise, and image, current power sector conditions mean that foreign investors are valued largely for renewable or advanced clean energy technology as well as their ability to help bring Chinese partners abroad.

88.1 **Foreign IPPs**

One effect of the evolving ownership structures of these key power-related industries has been uneven infrastructure investment both over time and across the electricity supply chain.

CYCLICAL INVESTMENT IN GENERATION INFRASTRUCTURE

The balance of investment in generation capacity relative to growing demand in China has gone through several cycles through the reform period. This can be explained in part by understanding the evolving incentive structures of major actors. In the first phase of power industry reforms, from the 1980s through the early 1990s, power supply was generally tight relative to rapid demand growth. To compliment its own investment capacity, the central government encouraged further investment in generation by local and provincial governments as well as private enterprises both domestic and foreign.[e] Local investment reached 41.2 percent of all generation investment by 1993, up from 14.4 percent in 1987.[f] Lacking comprehensive coordination, local and provincial government actors in particular rushed to invest in generally small capacity ad hoc thermal power plants to meet rapidly growing local power demands[g], and by 1997 generation capacity essentially met demand. One result of this rapid local growth however was that local generators were generally given preference over central government-invested or other non-local capacity by the provincial power distribution companies despite cost advantages[h], leading to inefficiencies in inter-provincial power transfer and driving up prices for end users despite adequate generation capacity.

Such inefficiencies led the central government to restrict investment in power generation, particularly small-capacity generation, in the late 1990s as part of the *Ninth 5-year plan* during a period of restructuring aimed at improving competition among generators and power transfer between provinces.[i] However, by the summer of 2002, shortages and rolling blackouts returned, especially along eastern industrial centres, in part because of less-than-adequate central large-scale investment over the preceding years to replace lost local investment. Such shortages continued for the following three years and into the next period of reform until rapid capacity growth by central, local, and private actors (both authorised and not), was able to alleviate the imbalance by about 2006.

The current generation investment environment in China is tight. Rapid growth in installed capacity among a diverse array of generators in recent years has surpassed growth in demand. As described below, pressures both up and downstream are squeezing generator margins, generally favouring the larger state-oriented generators who have the most flexibility and putting pressure on smaller generators, such as the remaining IPPs, to idle capacity, exit, or consolidate. This current situation, however, is sensitive to further reforms in the on-grid pricing system.

UNDERINVESTED POWER TRANSMISSION INFRASTRUCTURE

One carry-over from multi-phase power sector reforms has been uneven balance of investment between generation and

[g] *Xu and Chen 2006*

[h] *Hafsi and Tien 2003*

[i] *Chun Chun Ni 2006*

transmission/distribution infrastructure. Through the 1990s, and again in recent years, provincial and local governments as well as other IPPs could expect fair returns or capture other direct benefits by building and operating power plants, inducing widespread investment from diverse actors. Through each phase of power sector reforms, however, one element has remained largely unchanged— the central state-oriented monopoly on electric grid operation. Even when wealthy, coastal provincial governments in the 1990s may have benefited financially from more invest in their own provincial grid infrastructures, the regulatory conditions set by the central government for doing so were unclear, dampening interest.[j] So, with the central state-oriented grid monopoly[k] left as the primary source of grid investment, ratios through the 1990s reached about 1:0.2:0.2 for generation to transmission and distribution.[l]

This underinvestment in grid infrastructure has made for a non-robust dispatch schedule whereby generators are tasked to compensate for transmission fragility by managing their own loads across a broad range. This not only means that the generators themselves may not be able to operate at their most thermodynamically efficient loads, but also forces them to maintain economically inefficient fuel reserves. Such uncertainty in generation schedule also makes it more difficult to manage direct power sales beyond the NDRC-contracted annual power purchase agreement.[m]

Grid investment continues to be largely isolated from market signals and is determined through a bottom-up process whereby the central government (NDRC) aggregates investment requests made by local governments and other sub-bureaus into a broad investment guideline to be propagated over the course of a 5-year plan.[n] And because transmission and distribution tariffs are not determined competitively or even necessarily cost-based[o], the two state-oriented grid companies have little direct incentive to increase infrastructure investment. However, recent and current policy direction under the *Tenth* and *Eleventh 5-year plans* acknowledge this investment gap and outline massive increases in grid investment. Economy-wide, grid investment in 2004 increased 30.5 percent from the previous year, and grew another 40.0 percent in 2005, reaching CNY 158.6 billion (real 2005 USD 19.36 billion).[p] The *Eleventh 5-year guidelines* (2006-2010) calls for an additional CNY 1.2 trillion combined investment by the two grid companies, an increase of 90 percent over total investment through the tenth 5-year period.[q]

There is strong and growing demand for reliable and high-performance power grids in China. Just in recent years, total inter-regional transmitted electricity demand increased from 8.976 terawatt-hours in 2002 to 344.68 terawatt-hours in 2006, accounting 12 percent of total electricity generation. As a result, much of new grid investment will be directed toward achieving economy-wide long-distance interconnection, such as through the West-to-East and South-to-North power transmission projects, which aim to more efficiently distribute electricity resources throughout the economy.[r]

[j] *Hafsi and Tien 2003*

[k] *Pre 1998 Ministry of Power, post 1998 State Planning Commission.*

[l] *Ni 2006; International conventions for investment balance are generally 1:0.5:0.5, where transmission and distribution investment together approximately equals that of generation.*

[m] *Such marginal ex-PPA sales often make the difference between operating at a loss or a profit for generators with relatively high fixed costs, such as with hydropower.*

[n] *Varley 2006*

[o] *Simply put, realised grid tariffs are the residual between NDRC and local government-determined on-grid and end user prices.*

[p] *Though this grid investment is significant, it is still somewhat small compared to the massive CNY 522.8 billion (real USD 62.88 billion) total power sector investment estimated for 2006; Cui et al. 2008*

[q] *China Databar 2006, page 117*

[r] *China Databar 2006, page 117*

[s] *2006 figures.*

[t] *China Databar 2006*

[u] *Embassy of PRC 2004*

[v] *Huaneng Power International 2008 "FAQ"*

[w] *Liu Xiaoli 2008*

[x] *Investment in passenger rail line infrastructure was generally prioritized over that for freight in recent years.*

[y] *Sagawa and Koizumi 2007*

There are three main coal rail transport routes from west to east and north to south:

- The *northern route,* largest of the three by volume, has been made up by three lines since 2006: (1) Daqin line (from Datong in Shanxi to Qinhuangdao Port in Hebei; planned capacity: 100 million tonnes; actual 2005 load: 203 million tonnes); (2) Shenshuohuang line (from Shenmu in Shaanxi through Shuozhou in Shanxi to Huanghua Port in Hebei; planned capacity: 68.85 million tonnes; actual 2005 load: 110 million tonnes); and (3) Qiancao line (from Qiananbei in Hebei to Caofeidian Port in Hebei; constructed in 2006).

- The *central route* has 2 lines: (1) Shitai line (from Taiyuan in Shanxi to Shijiazhuang in Hebei; planned capacity: 75 million tonnes; actual 2005 load: 97 percent of capacity); and (2) Hanchang line (from Changzhi in Shanxi to Handan in Hebei; planned capacity: 15 million tonnes; actual 2005 load: saturated).

- The *southern route* has 2 lines: (1) Houyue line (from Houma in Shanxi to Yueshan in Henan; planned capacity: 80 mil tonnes; actual 2005 load: 101 million tonnes); and (2) Taijiao line (from Taiyuan in Shanxi to Jiaozuo in Henan; planned capacity: 50 million tonnes; actual 2005 load: 95 percent of capacity).

90.1 **Coal transport routes**

Industrial Map of China Energy 2006, see Atsuo Sagawa, et al 2003 for a schematic of transport routes

By 2006, the length of 220 kilovolt and above transmission and distribution lines was 281,000 kilometres, having grown annually by 11 percent since 2002. Current efforts, however, aim even higher, namely, the construction and integration of ultra-high-voltage transmission capacity with grids of different sizes and at different levels around the economy, something which has not been successfully implemented anywhere over long distances. The first ultra-high-voltage grid demonstration project, a power transmission network with 1,000 kilovolt AC and 800 kilovolt DC, will span 653.8 kilometres and cross both the Yellow and Hanjiang Rivers, transmitting power produced in Shanxi province to Henan province, and then to Hubei province. However, this demonstration project is now facing various challenges in regard to safety, economics, technology, and reliability.

Overburdened Coal Delivery Infrastructure

Coal infrastructure and investment is closely tied to that of power in China. About 45 percent of all coal consumption in China is used for power generation, and 79 percent of power generation uses coal.[s] Power supply security therefore relies on coal supply security—namely, timely fuel delivery. In recent years, bottlenecks in coal transportation infrastructure, particularly rail freight, have been blamed for power shortages. More investment is now directed toward rail-based coal transport to address this concern, but due to Chinese coal resource and demand geography, where coal is often transported long distances from central and western production regions to coastal power generation facilities, this area will continue to be a point for possible stress.

Of all transported coal in 2005, 16.9 percent was by water and 24.2 percent by road, while the majority, 58.9 percent, was by rail. These modal shares have been stable year to year since 2000. In fact, coal transport represented 47.9 percent of all rail transport at 1.29 billion tonnes in 2005, an increase from 41.3 percent and 690 million tonnes in 2000.[t]

Capacity shortages along these three major coal transport routes have been reported under normal summer peak-load conditions since 2004[u], requiring re-prioritisation of rail freight and passenger needs to ensure adequate supply of thermal coal to generation facilities. Major generators cited inadequate rail capacity as the cause of fuel shortages in 2005.[v] And in early 2008, severe disruptions along railways contributed to depleted fuel stocks for power generators in central and southern China and widespread blackouts.[w]

The central government has outlined infrastructure-based strategies to alleviate rail bottlenecks in coal transport through the *Eleventh 5-year guidelines*, including the construction of new freight lines, double tracking existing lines, separating freight from passenger lines[x], electrification, and increasing receiving capacity at seven ports in Hebei, Tianjin, and surrounding areas[y] which load ships for delivery to southern provinces. And while such upgrades are a needed response to the current situation, they do not directly address future system needs over the long-term; namely, that developed coastal centres will be unable to meet their growing power demands through local coal-based generation. As central China coal resources are depleted and production drifts towards massive northwestern Chinese coal basins over the middle to long term, and as efficiency or environmental concerns move to the fore, it will be increasingly attractive to transfer electricity rather than solid fuel to where end users need it by moving power generation to the mine mouth, or even to switch fuels for local generation. Aware of this, and as outlined elsewhere in this study, the central government has prioritised the construction on large scale mine-mouth thermal power generation through the reform period and continuing today.

THE UPSTREAM/ DOWNSTREAM PRICE GAP

The power generation sector is caught between a liberalised market for its fuel input and a government-guided market for its electricity output. Through what is essentially a single-buyer model, generators negotiate annual power purchase agreements with provincial and central-level development and reform commissions.[z] Thermal coal contracts have traditionally also been negotiated at an annual conference of power generator and producers, and guided by central government authorities from NDRC and the Ministry of Railways, though this has been cancelled since 2007 in favour of more direct negotiations between sellers and buyers.[aa] However, in recent years, under an unstable domestic coal price regime, the final share of annual generator fuel needs negotiated under annual contracts has declined to less than half in 2004[bb], though this varies by generating company. Meanwhile, out-of-plan/ contract spot market domestic thermal coal prices have gradually widened their premium over in-plan prices, moving from approximate parity in 2000-2001 to a nearly 35 percent gap in 2006.[cc] As fuel prices rise through the year, thermal generators may choose to reduce output or subcontract to hydropower generators, for example, to meet power purchasing agreements.

On-grid tariff reforms outlined by the State Council in 2005 are meant to address this issue by allowing up to 70 percent of fuel price increases over a six-month period to be passed through to end users. But, this time lag still leaves generators with an incentive to draw down fuel stocks as coal prices rise in hopes that spot market prices may drop or in the belief that the central government would rescue the industry in case of a severe fuel shortage. Either threatens the security of power supply. Moreover, this cost pass-through policy has seldom been exercised for fear of adding inflationary pressure on end users, and final realisation of the coal-power price linking mechanism is uncertain. By June of 2008, for example, amid fair weather but rapid increases in the price for domestic and international thermal coal and in the run-up to summer peak power demand, the Chinese Electricity Regulatory Commission estimated that 41 turbines representing over 6 gigawatts— nearly 1 percent of economy-wide power generation capacity— had been idled, with average stocks at less than seven days across numerous provinces, driving some provincial governments to institute coal price caps, further threatening supply security.[dd]

Of course, this price gap also affects generator profitability. However, abilities to absorb such price fluctuations vary by company

In 2006, coal production was 160 million tonnes, of which 115 million tonnes were sent out of the province. About 50 percent of all energy produced in the province is now exported, some as part of the West-to-East power transfers scheme, and this share will increase to ~70 percent by 2030— most of that in the form of raw coal. Currently, however, railway transport is strained and achieves only a 40 percent satisfaction rate. To address this, the provincial government plans to expand transportation capacity, in part by developing separated rails for freight and passenger transport: 30 percent of such transport infrastructure investment will come from local governments in the form of land and construction management, while 70 percent will come from the central government directly or in-kind.

91.1 Shaanxi coal and energy transport, a producer's perspective

[z] *In some areas, on-grid tariffs are determined in consideration of plant technology and age varying by province.*

[aa] *Huaneng Power International 2007*

[bb] *Melanie and Austin 2006*

[cc] *CNY 265 versus CNY 357 per tonne for mine mouth steam coal; Sagawa and Koizuni 2007*

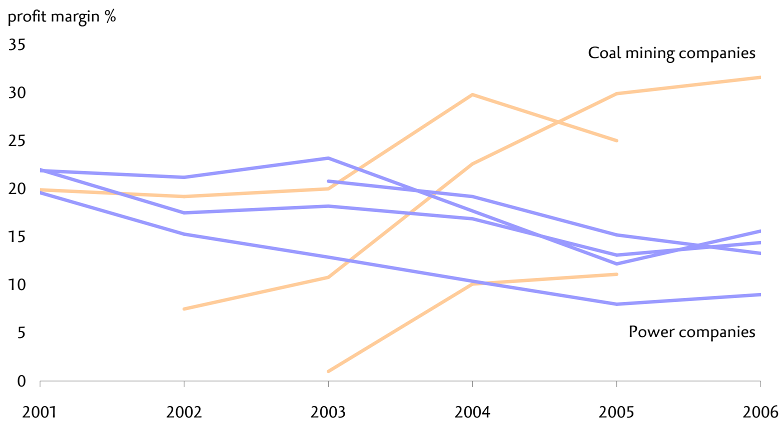
[dd] *Yang Yue 2008 "Coal Stocks Shrink for Chinese Power Plants"; Li Qiyan 2008 "Coal Shortage Strains Chinese Power Plants"; China Coal Resources Net 2008*

Hunan lacks energy resources, and in particular conditions are poor for coal exploration and production. Therefore, in order to meet coal demand, it is necessary to import coal from other provinces. Currently, many Hunan power generation facilities contract directly with specific coal mines outside the province, in Guizhou, for example, to supply coal, as is common elsewhere in China. In the short- to mid-term, however, some Hunan power companies plan to actually locate their thermal generation plants inside nearby relatively resource-rich areas such as Guizhou for direct off-grid sale to Hunan end-users. Most inter-provincial coal imports to Hunan come by rail, with only very small amounts by truck or waterway (primarily from Shanxi, Henan, Ningxia, Shaanxi, Guizhou, Yunnan, and Sichuan, with some exports/re-exports to Guangdong). Hunan total coal consumption is roughly 70-80 million tonnes, of which 40 percent of coal is used for power, and by 2020, 40 percent of coal consumed is projected to come from outside the province. Coal freight capacity for inbound rail traffic has become somewhat tight, but is expected to be addressed as part of economy-wide rail freight upgrades.

92.2 **Hunan coal and energy transport, a consumer's perspective**

profile and exposure, with the larger, capital-rich, state-oriented generators generally better positioned than smaller IPPs. For example, China Huaneng Group, the economy's largest generator, is typical of many thermal generators in that the largest expense is fuel— over 63.5 percent in 2006.[ee] And despite being China's most thermally efficient publicly-listed generator, Huaneng's power production lost CNY 80 million (real 2005 USD 8.5 billion) in the first quarter of 2008 citing that a "significant increase in thermal coal prices led to a decrease in the consolidated net profit".[ff] However, benefiting from its scope and ability to absorb losses that might overwhelm a smaller enterprise, Huaneng was able to nevertheless achieve an overall net profit of CNY 150 million (real 2005 USD 15.9 billion) in the same quarter.[gg] Meanwhile, Huaneng, along with other major generators flush with capital including Guodian and Datang, have been able to respond to the coal price increase by increasing stakes in coal mining and even transportation operations, increasing investment in mine-mouth generation, and leveraging fuel-insensitive generation capacity such as hydropower and renewables.[hh]

And though margins have been declining even for these major generators as competition has increased and pricing has remained tight, particularly relative to the mining industry, this squeeze will likely benefit major generators in the middle to longer term as they move to acquire struggling small-scale industry competitors who now suffer the most. The price gap is therefore driving consolidation across the power industry, both horizontally and vertically.[ii]



92.1 **Profit margin for publicly-traded Chinese coal and power companies**

Thomson Financial in Rosen and Houser 2007

[ee] *Almost all Huaneng electricity production is from coal, with only a small amount of hydro in Sichuan Province; Huaneng Power International 2007*

REFINING

Consumption of petroleum products, though relatively less crucial to the Chinese economy today than power consumption, is nevertheless significant and continues to grow. Over the last five years, an increasingly mobile and industrialised China has added about 20 million tonnes of new refining capacity each year. Similar to the power sector, China currently sees only limited international trade in refined petroleum products as a share of its total consumption.[jj] And though unbalanced investment is less an issue for the refining sector than in the power sector, refineries are similarly squeezed by rising upstream market prices for crude oil unmet by downstream state-guided product prices.

The industry structure of oil refining in China is not fully transparent. The large state-oriented players, Sinopec (26 refineries, 160 million tonnes per year capacity) and CNPC (24 refineries, 120 million tonnes per year)[kk] compete with a number of smaller local and private refineries (estimated capacity 80 million tonnes in 2005) as well as unlicensed teakettle refineries[ll]. Moreover, shares of yearly production across these actors are obscure.

However, since oil sector structural reforms were enacted in 1998 to create vertically-integrated state-oriented enterprises Sinopec and CNPC, it is clear that these two giants are and will continue to be the refining sector's dominant players. Both have significant but uneven upstream and downstream presences. CNPC, including its publicly listed subsidiary PetroChina, has extensive overseas and domestic crude production to feed its refinery operations, while Sinopec, with more limited upstream capability and a larger refinery capacity, must import approximately 80 percent of its feedstock[mm]. Both also have near regional monopolies on product distribution service areas, Sinopec in the North, East, South, and Southwest and CNPC in the Northwest, Sichuan Province, and parts of the Northeast.[nn]

THE UPSTREAM/ DOWNSTREAM PRICE GAP

Like the Chinese power generation sector, petroleum refiners are caught between a largely liberalised market for feedstock inputs (namely, crude oil) and a command-based market for refined product output. While refiners must buy at international prices, their domestically distributed product, including gasoline and diesel fuel, is sold at prices determined by the central government's NDRC. And though product prices are adjusted to reflect changes in a basket of international crude and product prices[oo], there is generally a time lag of several months as a result of NDRC's consideration of consumer affordability and market supply and demand. For example, recently, during a period of rapidly rising international crude price, the NDRC delayed product price adjustment in part to avoid contributing to domestic inflation. And as in the power generation industry, this has squeezed refiners and introduced threats to the security of smooth petroleum product supply in China.

[ff] *Huaneng Power International 2008 "Power generation increases 18.62% in the first quarter of 2008"*

[gg] *Wan Zhihong 2008*

[hh] *Wang Lan 2008*

[ii] *For discussion of miner, generator, and grid profit margins since 2000, see Rosen and Houser 2007 and China Databar 2006, page 133.*

[jj] *Electricity import to China from Russia, North Korea, and Hong Kong, China in 2006 reached 0.5 terawatt-hours while electricity export to neighbouring economies such as Hong Kong, China, Macau, Vietnam and North Korea was estimated at 1.29 terawatt-hours, an increase of 10 percent from the previous year. For petroleum products, net import was about 16.7 million tonnes in 2005, 5.9 percent of total final consumption and an 11 percent decrease from net import in 2004.*

[kk] *Along with international joint ventures including the 10 million tonne per annum, hydrocracker-equipped Dalian West Pacific Petro-chemical, a venture of Sinochem, PetroChina and Total which began initial operation in 1996; Total China 2008*

[ll] *Tu Jianjun 2008; The number, capacity, and throughput of China's teakettle refineries are disputed – on the higher end, Argus Media (2008) puts them at 21 percent.*

[mm] *Poon and Yung 2008*

[nn] *For more details on product distribution in China, see Guo Sizhi 2003.*

[oo] *Since 2007, NDRC has followed an approximate cost-plus product pricing model, targeting refiner operating margins of roughly 5 percent; see Zhang Yue 2008 and "Energy Pricing" section of this report.*

This highlighted tension for the two major state-oriented petroleum enterprises to balance their motivation to seek profit with responsibility to ensure supply is a common point for discussion. In reality however, the balance is likely one of time: as state-owned companies, there is little question that the responsibility to ensure a generally stable fuel supply trumps profit motivations in the short-term. According to Jiang Jemin, Chairman of PetroChina and quoted in March 2008, "We...have to shoulder some social responsibility, such as ensuring the supply of refined oil products in China. So when there is some conflict, some sacrifice will be required." [Ed Crooks and Robin Kwong March 19 2008] Over time, however, this social responsibility can easily be compensated by a central government that is equally vested in ensuring the long-term security, performance, and financial viability of its energy suppliers. Energy markets in any economy are a product of both policy and market forces, and in a centralised China, each is a commonly used tool to achieve energy or other development goals.

94.1 **Balancing profit with social responsibility**

The result of this widening price gap in the refining industry has been declining profit margins, increased pressure on product exports as refiners try to capture international refined product price levels, and periodic regional product shortages. Sinopec representatives have estimated their refining break even point in recent years to range at costs between USD 58[pp] and USD 68.5 [qq] per barrel of crude, and CNPC's PetroChina estimated USD 69.4.[rr]

Unlike power generators, however, China's major refiners are somewhat insulated from a widening price gap. Foremost, CNPC's enterprise structure forms a natural hedge against such price differentials, with substantial upstream windfall revenues from crude production effectively subsidising refining and distribution operations. And Sinopec, which produces far less crude but more product, is routinely subsidised by the central government in case of declining profit margins, either by raising end user product prices[ss], giving tax breaks and refunds on imported crude[tt], or through direct payments.[uu] In 2008, both firms, including for the first time CNPC's PetroChina, announced that they will begin receiving monthly central government subsidies to offset rising costs.[vv] Their domestic competitors, however, including small local and private refineries, will continue to suffer. Already placed at a disadvantage by their small allocations of domestic crude production and by restrictions on the import of crude feedstock from the international market, these small, market-driven refiners have strong support from the provincial and local governments whose economies they support but are viewed with general ambivalence by the centre.[ww] Faced with low capacity utilisation rates, small capital reserves, and an unfriendly market, these local and private producers have become targets for takeover by the relatively stable oil majors.[xx] This horizontal consolidation driven by large state-oriented enterprises under broadly unfavourable operating conditions mirrors the phenomenon already observed in the power generation sector.

IMPLICATIONS FOR CONTINUED REFORM

The major midstream energy industries outlined here, power generation and petrochemical refining, face similar challenges. And though they come from different places, they have reacted similarly—through consolidation and vertical integration. This strategy, also seen now in the coal mining industry, has been driven by both government and business concerns.

From one perspective, this push to strengthen the market share and influence of the larger and most advanced state-oriented enterprises is quite reasonable given the conditions faced in ongoing Chinese energy development. For example, the vertical integration of power generators with coal mining, transportation, and even electricity generation is a reasonable short-term response to unbalanced or rapidly shifting profit potential across the power supply chain over time. If, like in the oil sector, power companies could internally compensate weak generation profits with strong mining profits, then there is less pressure to reform complex pricing systems that might have undesired broader implications for affordability among end users in the economy. As an

pp *Downs 2006*

qq *Crooks and Kwong 2008*

rr *All values are real 2005 USD; Crooks and Kwong 2008* added benefit, a more centralised and financially sound power generation industry might also be more able to implement government policies and afford advanced large-scale technologies and other practices that could improve efficiency or environmental performance in the sector. A similar story could be told in the refining sector, where the major players are encouraged to both vertically integrate along the petroleum supply chain as well as increase market share in refining itself, allowing for better coordination.

But it is also important to consider that the short-term desirability of such an approach may have long-term implications for market-oriented reform and liberalisation in these key energy sectors. Simply ensuring energy enterprise profitability is not a sustainable substitute for the continued energy pricing reform that the central government has been so successful in implementing through the reform period. This is particularly true for optimising energy resource allocation into the future—with the increasing size and complexity of the Chinese energy market, the government and individual enterprises will unable to balance the interests of all parties without clear price signals. And even state-oriented energy enterprises with significant market share and facing little intra-sectoral competition will face contradictions in harmonising the pursuit of rent and social responsibility in such an environment. Consolidation and vertical integration as a substitute for broader market liberalisation may also hurt the competitiveness of Chinese energy industries on the international market, both abroad and domestically. Already, vertical integration of state-oriented petrochemical enterprises has been cited by host economies as a reason to proceed cautiously with upstream resource investment rights.[yy] And in the long-term, though consolidation could be a precursor to more openness for international investment and even direct competition in the domestic Chinese energy market by strengthening the survivability of existing Chinese energy enterprises, it could ultimately discourage advanced foreign operators from the Chinese market if they feel they would be operating at a competitive disadvantage. In the sense that this could limit the use of advanced technologies and procedures inside China, as well as overall competition, it deserves consideration.

[ss] *Which, with oil's distribution scheme and relatively more limited scope to affect the Chinese economy, is done on a more fluid basis than end user tariffs in the power sector, in addition to the contracted lobbying power of the two refining majors. For more on lobbying power, see Downs (2006), and for an example of an individual refinery's attempt at relief, see Yang Yue (2008) "Refiners squeezed by China's oil price gap".*

[tt] *A refund of the 17 percent tax on crude imports, as was announced for both Sinopec and CNPC in April 2008 for imports in the second quarter, with speculations that this tax would be substantially reduced into the future; see China Economic Net (2008) and Rosen and Houser (2007).*

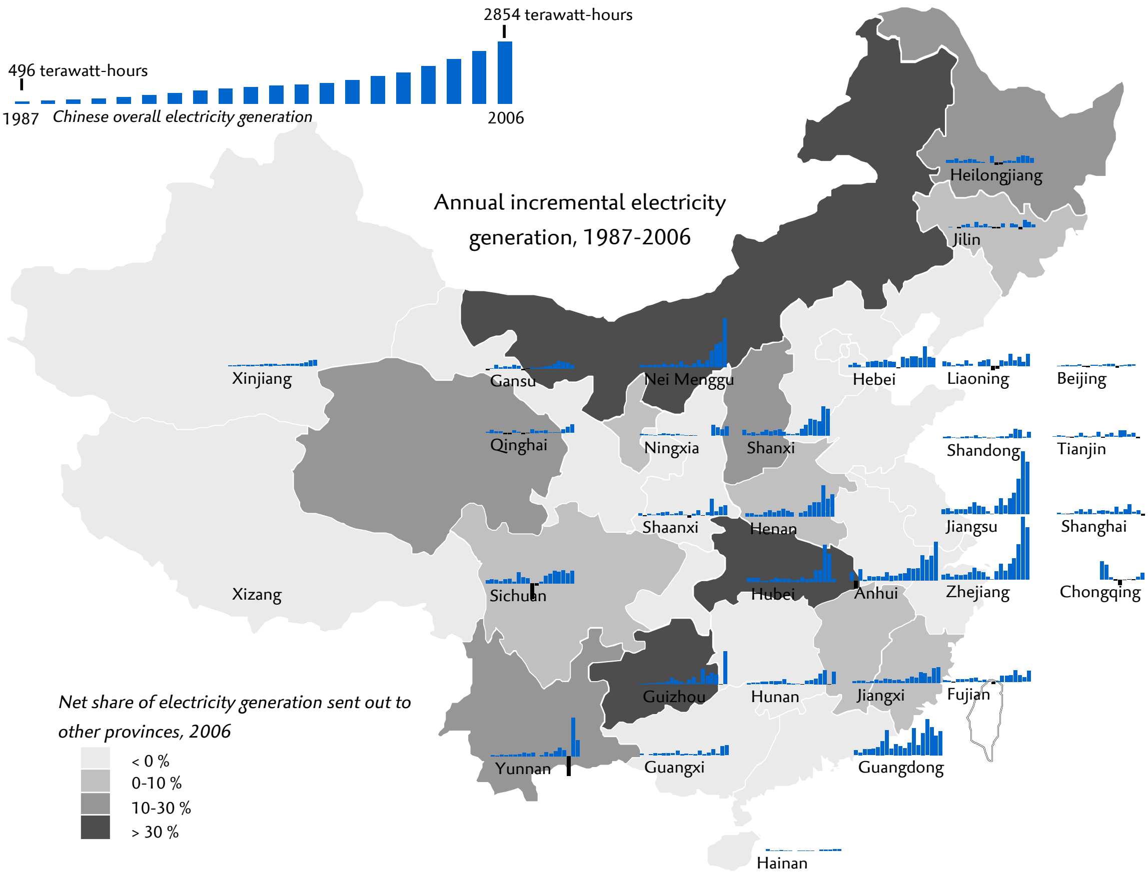
[uu] *In 2006-2007, year-end subsidies were granted to Sinopec; Li Qiyan 2008 "Tough times for Chinese power, oil firms"; Rosen and Houser 2007*

[vv] *Poon and Yung 2008*

[ww] *Tu Jianjun 2008*

[xx] *Soble 2008*

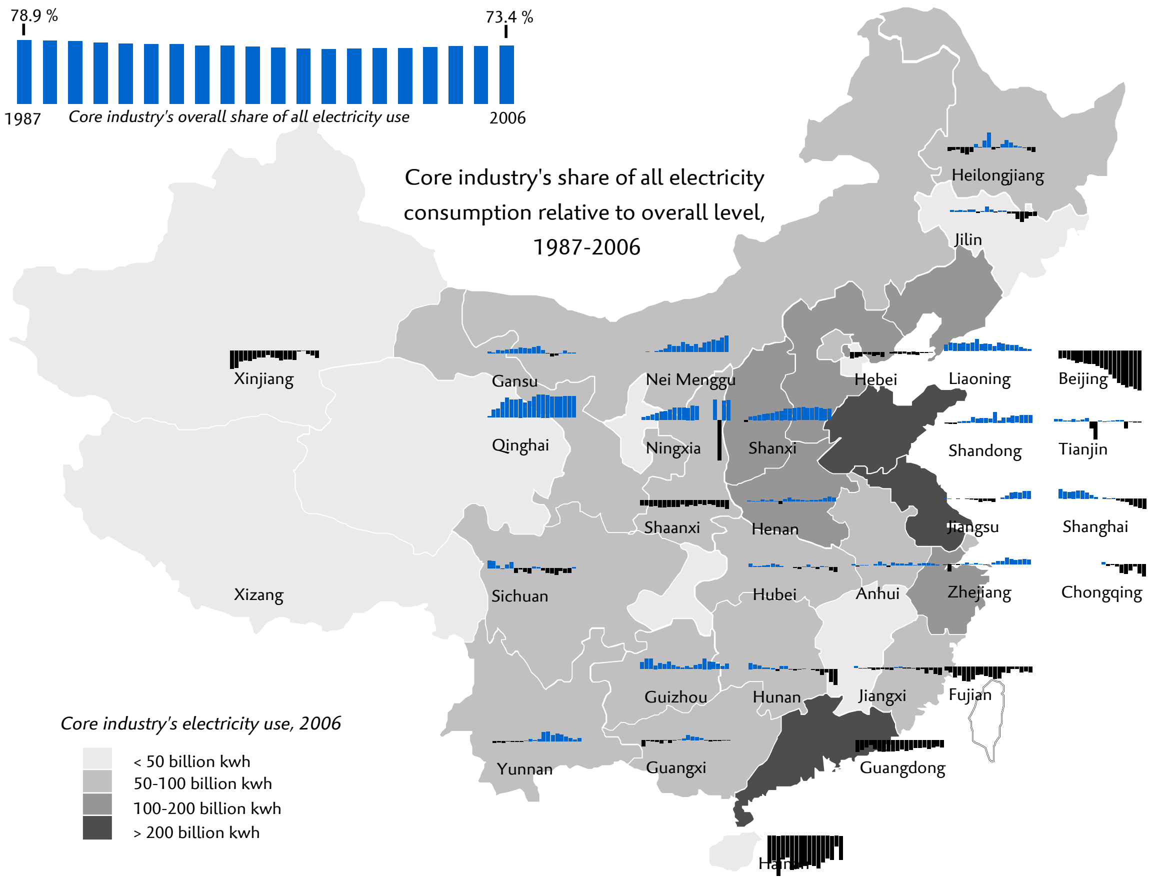
[yy] *Economist 2008*



96.1 **Electricity generation**

APERC 2008

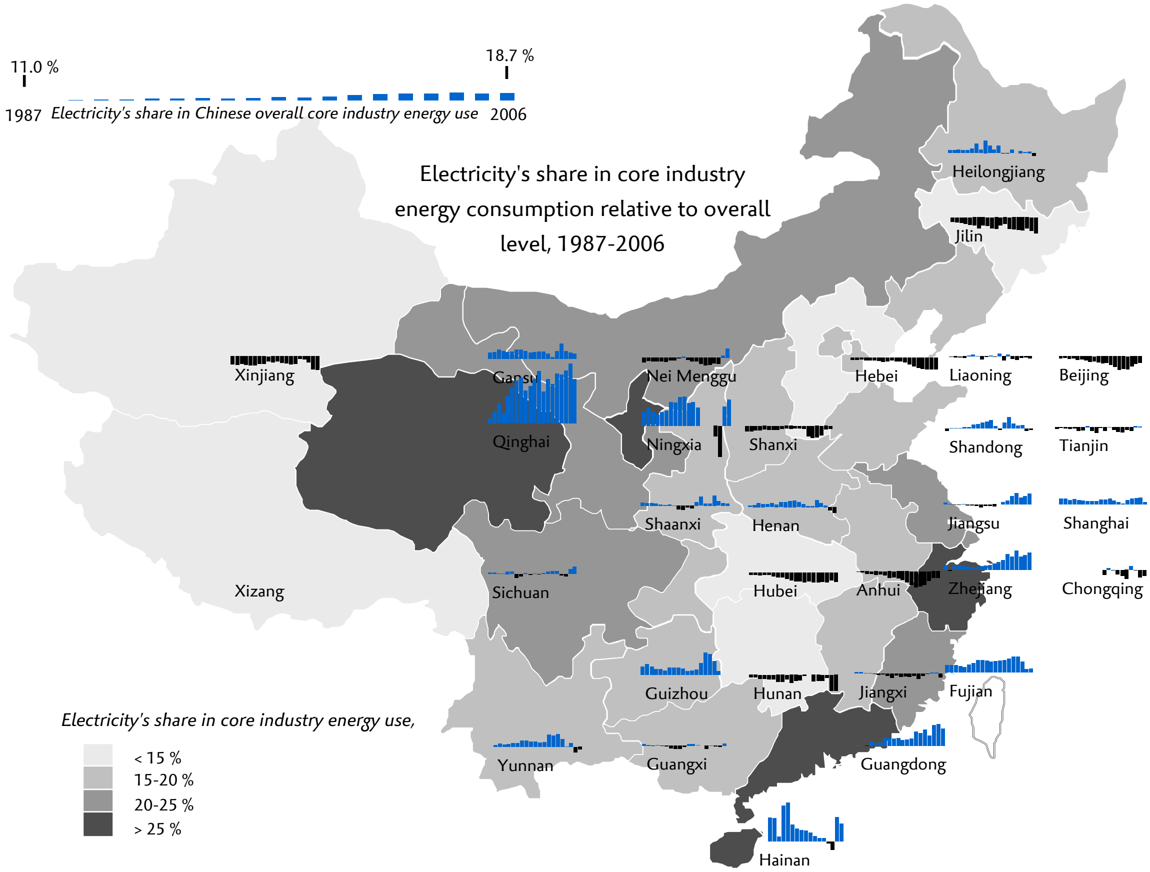
- Overall, electricity generation growth accelerated from 496 terawatt-hours in 1987 to 2854 terawatt-hours in 2006. Growth was particularly rapid post-2000 following a slowing of growth in the late 1990s.
- Regionally, annual incremental electricity generation was particularly strong following the late 1990s in about one-third of provinces across China, while generation growth was less pronounced or even flat in other areas. Guangdong stands out for its early and continued incremental growth in generation. Production declines anywhere were rare.
- Some provinces transmit a significant share of produced electricity out to other provinces. This net share exceeds 30 percent in Guizhou, Hubei, and Nei Menggu and is quite low in eastern coastal provinces.



97.1 **Core industry electricity use**

APERC 2008

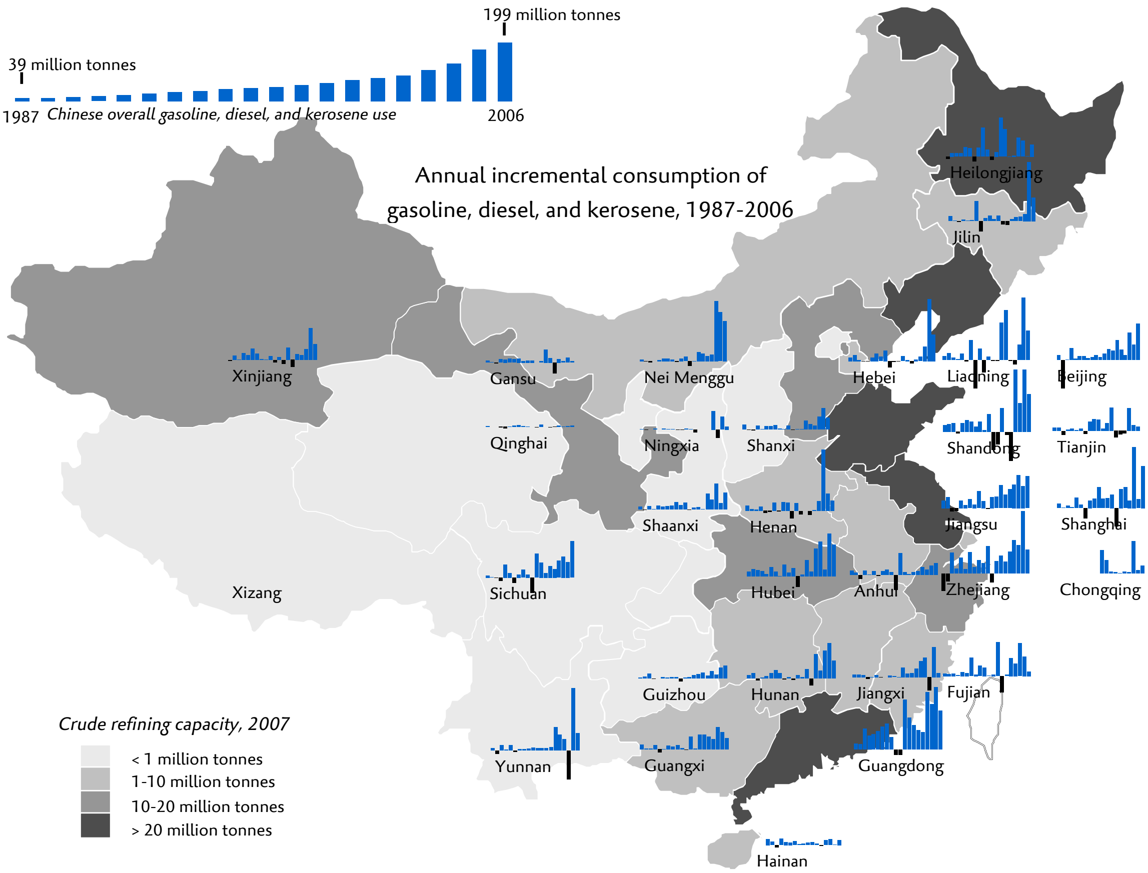
- Overall, core industry continues to use nearly three-quarters of consumed electricity, though it's share of consumption declined slightly from 78.9 percent in 1987 to 73.4 percent in 2006., having stabilised at about that level since the late 1990s.
- Regionally, core industry is a relatively more important consumer of electricity in those western provinces where it was a relatively less important consumer of coal. Core industry's share of electricity consumption is slightly lower in Guangdong and Fujian.
- The total amount of electricity used in core industry is highest in Guangdong, Jiangsu, and Shandong, each province exceeding 200 billion kilowatt-hours annually.



98.1 **Electricity's use in core industry**

APERC 2008

- Overall, the share from electricity for core industry energy needs gradually rose, from 1987 when final consumption of electricity represented 11.0 percent of energy use up to 18.7 percent in 2006. This 7.7 percentage point increase accounts for just over half the 13.9 percentage point decline from final consumption of coal.
- Regionally, provinces gradually diverged in the share of energy from electricity for core industry. Starting at low average levels in most regions in 1987, Guangdong, Fujian, and Zhejiang, for example, gradually increased their share of core industrial energy from electricity, while Hubei and Anhui, as well as Hebei and Jilin, gradually declined.
- Regional variation in electricity share is not clearly correlated with regional variation in coal share for core industry energy use.
- Electricity's share in core industry energy use is particularly high in Qinghai, and also high in Ningxia, Zhejiang, Guangdong, and Hainan.



99.1 **Gasoline, diesel, and kerosene use**

APERC 2008

- Overall gasoline, diesel, and kerosene petroleum product use in China increased with gradual acceleration from 39 million tonnes in 1987 to 199 million tonnes in 2006.
- Regionally, more provinces saw higher incremental consumption of these petroleum products since about 2000.
- Refining capacity is highest in Heilongjiang, Liaoning, Shandong, Jiangsu, and Guangdong.

ENERGY EFFICIENCY

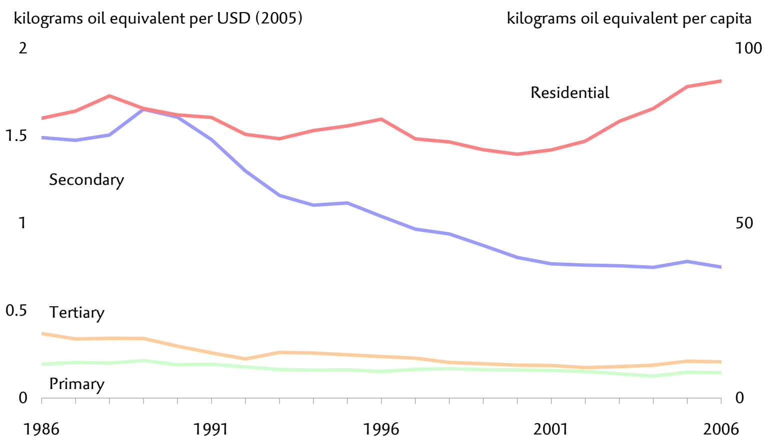
Since the outset of the reform period, energy conservation has been prioritised as key to sustaining energy and economic development in China, encouraged by the central government though various policies, regulations, and measures. Following adoption of this basic stance, energy consumption per unit GDP[a] continuously decreased until 2002, gradually rising thereafter. In response, the central government in 2004 published the *China medium- and long-term energy conservation plan* to emphasise the principles and objectives of energy conservation, to provide targets for energy consumption reduction and efficiency improvement of major products and energy consuming equipment, and to underline key energy conservation areas and projects with implementation measures. In addition, through the 2006 *Eleventh 5-year guidelines*, the central government targeted a decrease in energy intensity by 20 percent by 2010 from the 2005 level. **[105.1]**

[a] *Hereafter, energy intensity.*

Generally, such energy intensity reductions can be achieved in two ways: (1) by adjusting the economic structure so as to encourage high value-added industrial as well as services and commercial sector development, and; (2) by improving efficiency through technology in energy transformation and end-user sectors or by implementing other energy-efficiency improving management and design. This section focuses on the policies, targets, and programmes implemented to achieve efficiency improvement in those sectors with high potential, including energy-intensive industries, residential and commercial sectors, and power generation. It also includes a brief introduction to related aspects in the most recent *Eleventh 5-year guidelines.*

TRENDS

Energy intensities in primary, secondary, and tertiary industries decreased on the whole between 1986 and 2005, and the greatest declines were in secondary industry **[101.1]**. Over the same period, residential energy consumption per capita increased slightly due to improvements in living standards and subsequent higher demand for commercial energy.



101.1 **Energy intensity of industry & residential per capita energy consumption (1986-2006)**

APERC 2008

INDUSTRY	SUBSECTORS
Primary	Farming, forestry, animal husbandry, fisheries and water conservancy
Secondary	Industry (mining and quarrying, manufacturing, electricity generation and supply, steam, hot water, gas) and construction
Tertiary	Transport, storage, post and telecommunications, wholesale, retail trade, catering, hotels, and other industries not listed elsewhere

102.1 **Chinese industrial categorisations for final energy consumption**

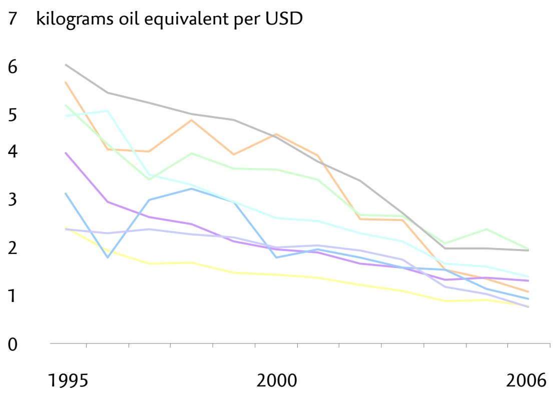
NBS and APERC 2008

INDUSTRIAL SECTOR

Key to achieving energy conservation in China is increasing energy utilisation efficiency— the energy consumption per unit of output value. Generally, with higher energy utilisation efficiency, energy demand growth can be moderated. Since the beginning of *Sixth 5-year plan* period coinciding with the outset of the reform period, secondary industry energy intensity fell from 2.05 kilograms oil-equivalent per real USD in 1981 down to 0.75 kilograms per real USD in 2004 before reversing this trend to rise up to 0.78 kilograms oil-equivalent per USD in 2005. Over this 24-year period, the energy intensity declined 62 percent, or at an annualised rate of 3.9 percent. The rise during the *Tenth 5-year plan* period was due in part to fast energy demand growth in the energy-intensive industries of steel, aluminium, and cement alongside robust growth in output volume.

Energy intensity per unit of value-added output in selected industrial subsectors showed a declining trend over the past eleven years **[102.2]**. Raw chemical materials and chemical product manufacturing reduced intensity from 4.32 kilograms oil-equivalent per real USD in 1995 to 1.23 kilograms oil-equivalent per USD in 2006, an annualised reduction of 10.8 percent, the fastest among industrial subsectors. Moreover, similar declines are true for energy efficiency expressed in terms of energy consumption per physical unit of major product output. Energy efficiency improvements in the industrial sector are primarily due to increased penetration of energy-saving equipment as well as technology/ process breakthroughs, such as switching from wet to dry processes in cement production, recycling of waste heat in the iron and steel industry, and more generally the upgrade of equipment and construction of new large-scale facilities. And although industrial energy intensity has been decreasing in recent decades, the current energy intensity level is still 25 to 60 percent higher than the advanced international level.[b] Thus, there is still substantial room for energy efficiency improvement in industry sector.

[b] *Manufacture of paper and paper products, one of the worst performers, exceeds international level energy intensities by 120 percent.*



102.2 **Energy intensity of industrial subsectors (1995-2006)**

APERC 2008

Residential and Commercial Sectors

In general, energy end-use efficiency of residential and commercial sectors increased from 29 percent in 1980 to 72 percent in 2005.[c] Energy consumption in these sectors occurs mainly in buildings in order to provide space heating, air conditioning, ventilation, lighting, water heating, and appliances or other equipment, so there is reduction potential in these areas. For example, in northern areas such as Liaoning, where heating requirements are significant, there is effort to improve the efficiency of and conservation in neighbourhood central heating systems. Guidelines on the use of building materials and design features in residential buildings published in Beijing, Shanghai, and other cities have been a valuable step in improving building energy efficiency. Increasing the energy efficiency of lighting, electric equipment, and appliances is another key measure to save energy in buildings. For instance, through the implementation period of the Green Lighting Program, the ratio of energy saving fluorescent lamps to incandescent lamps increased from 1.0:8.2 in 1996 to 1.0:2.6 in 2002 and was estimated to have mitigated demand for around 4.1 terawatt-hours of electricity in 2002 alone. Other energy efficiency standards have been developed for household appliances, commercial equipment, and industrial equipment since 1987. Recently, labelling according to updated standards has become mandatory, with the first batch of labelled household refrigerators and room air-conditioners released in March 2005.

[c] *Here, efficiency is defined by the relationship between useful energy and final energy. This 2005 level was the approximate equivalent of the 1990s international level; Cui et al. 2008*

	UNIT	CHINA	INTERNATIONAL	POTENTIAL
Coal consumption of power supply	goe/kWh	262	218	-17%
Comprehensive energy consumption per tonne of steel	kgoe/tonne	519	427	-18%
Comprehensive energy consumption of copper smelting	kgoe/tonne	546	240	-56%
Comprehensive energy consumption of aluminium	kgoe/tonne	6717	4158	-38%
Energy consumption of unit energy factor of oil refining	kgoe/tonne	51	51	-
Comprehensive energy consumption of ethylene	kgoe/tonne	483	440	-9%
Comprehensive energy consumption of large scale synthetic ammonia	kgoe/tonne	910	679	-25%
Comprehensive energy consumption of cement	kgoe/tonne	104	89	-14%
Comprehensive energy consumption of plated glass*	kgoe/tonne	18	10	-44%
Efficiency of coal-fired industrial boiler (under operation)*	%	60-65	80-85	15% points
Efficiency of medium and small sized motor (design)*	%	87	92	5% points

103.1 **Energy conservation potential of industry sectors (2005)**

**represents 2000 values*

APERC 2008, NDRC energy data 2007, Wang Qingyi 2003 "China National Energy Strategy and Policy 2020"

Power Sector

Power sector efficiency has gradually improved through the reform period due to technology innovation, change in thermal energy mix, and policies such as the closure of small-sized inefficient thermal power units. Coal consumption for thermal power supply declined from 448 grams per kilowatt-hour in 1980 to 367 grams per kilowatt-hour in 2006, an annualised reduction of 0.8 percent. Over the same period, the share of total generation used for power plant (own-use) operation decreased at an annualised rate of 0.3 percent, attaining 6 percent in 2006. For thermal power generation, water consumption dropped from 4.1 kilograms per kilowatt-hour in 2000 to 3.1 kilograms per kilowatt-hour in 2005. Additionally, the rate of electricity loss in transmission and distribution networks declined to 7.08 percent by 2006.

These technology-based efficiency gains in power generation were not haphazard. The central government first used imported 125 megawatt and 200 megawatt power generation units in the 1970s. By the 1980s, 300 megawatt and 600 megawatt power generation technology was introduced and used as a basis for local research and development in order to produce such equipment domestically. With domestic technology development, the size of installed units shifted from 100-200 megawatts in the 1980s to 300-600 megawatts in the 1990s. A number of energy conservation and efficiency improvement policies also directly encouraged technology development and penetration, for example, the 1990s stipulation that newly added power generation units should be designed to achieve coal consumption of less than 330 grams coal-equivalent per kilowatt-hour.

The central government also developed various economic measures such as import tax exemption and special funds for technology innovation to encourage the introduction of advanced technology from other economies. Subcritical pulverised coal combustion technology was introduced from the US and was employed for power generation in China from the 1980s. Following that, coal-fired power generation technology in China developed from subcritical PCC to supercritical PCC and further to ultra-supercritical PCC alongside the expansion in size of individual units from 300 megawatts to 600 megawatts and 1,000 megawatts. Currently, the design, manufacture, construction and operation of 600 megawatt supercritical PCC power generation technology is essentially mature in China, and the design of 1,000 megawatt ultra-supercritical PCC technology is basically well known. Domestic manufacture of 1,000 megawatt ultra-supercritical PCC power plants began in Zhejiang at the end of 2006.

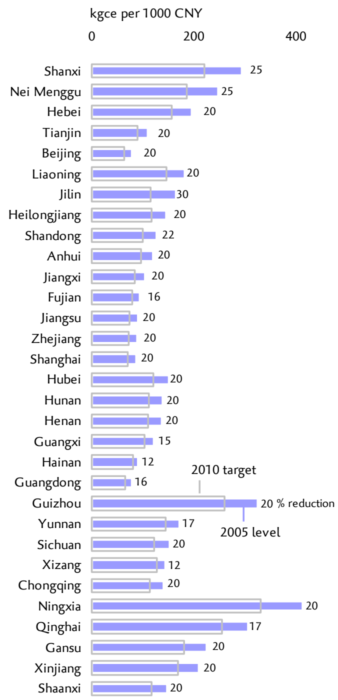
Currently, there are three key domestic power generating equipment manufacturing enterprises in China: Shanghai Electric Group Co. Ltd, Harbin Power Equipment Corporation, and Dongfang Electric Corporation. These players together represent 80 percent market share for domestic production and 73 percent market share for domestic sales.[d] Each of these key manufacturing enterprises has cooperated with numerous foreign companies on domestic production of boilers, steam turbines, gas turbines, and auxiliary equipment related to power generation. And besides expanding their domestic market, they have

[d] *US Department of Commerce 2006*

also focused on exporting their equipment overseas, in particular to developing economies in the APEC region such as Vietnam and Indonesia. As key Chinese power enterprises have developed from technology importers to technology exporters and from joint-ventures to self-reliant design, manufacture, construction and operation, they now hold considerable potential to translate their own efficiency improvements into broader regional gains throughout APEC.

POLICY AND INVESTMENT

Since enshrinement of energy conservation in China's energy and economic development strategy in the *Sixth 5-year plan*, numerous supporting policies and regulations have been established. In 1986, the State Council released the *Energy conservation management regulation* for industrial and residential energy consumption as well as for efficient technology development. In the same year, the *Enterprise energy conservation reward* was announced to encourage energy saving. In 1987, the State Council issued reinforcement regulation for energy conservation in the power sector so as to encourage electricity utilisation management and the use of energy saving equipment and technology. Between 1994 and 1995, the central government released various guidelines to improve energy efficiency of ventilating fans and water pumping systems and also provided funds to encourage industry equipment upgrade. And in 1996, energy conservation technology development outlines were issued that charted the desired direction of technology development among different industries. The first *Energy conservation law* was promulgated in 1997 and took effect in 1998. However, these regulations were not implemented as expected, with especially slow progress in establishing relevant regulations. For example, the energy efficiency standard for industrial equipment was limited to just a few products, including motors, pumps, transformers, and compressors.



105.1 Provincial energy intensities and target reductions

APERC 2008, NDRC 2008

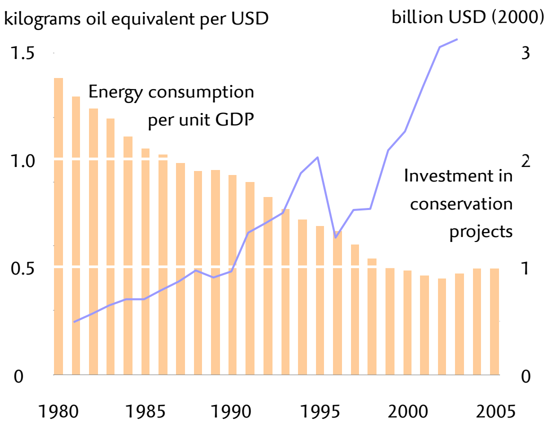
Release of the *China medium- and long-term energy conservation plan* by the National Development and Reform Commission (NDRC) in 2004 highlighted the central government's desire to integrate energy conservation into long-term energy development. The plan outlined medium and long-term energy conservation projects in the industry, transport, building, residential, and commercial sectors, with implementation measures specified through the *Eleventh 5-year plan* period (2006-2010) as well as the period 2010 to 2020. The plan's targets for reduction of energy consumption index of major industrial products and energy efficiency indicators of major energy consuming equipment were also included in the *Eleventh 5-year guidelines for energy development*, released in April 2007. The *Energy development plan*, in turn, noted that existing coal industry, electric power, and energy conservation laws would be revised and new laws formulated in the oil and natural gas industry in order to improve the environment for market-based economic development in the energy sector. In December 2007, the fifth edition of the draft *Energy law* was distributed for public comment. This draft law covered both energy management and energy saving, and included such provisions as the expansion of energy taxes so as to adjust energy consumption and promote efficient use.

In order to reduce the energy consumption in industry through industry restructuring, China promulgated the *Interim regulation on promoting the adjustment of industrial structure and guiding catalogue for industry restructuring* in 2005. These updated guidelines, released to respond to the economy's rapidly-changing industrial structure in recent years, outlined "encouraged", "restricted", and "to-be-eliminated" categorisations across 20 major industries. Financial institutions, permitting agencies, and local governments were directed to refer to these updated guidelines in assessing new and existing investments.

106.2 **Industrial restructuring policy**

NDRC December 22 2005

In 1981, the central government established a special fund to support energy conservation and technology development projects. In addition, the government also provided various financial incentives to mobilise investment in energy conservation such as low-interest loan programmes and tax credits for energy efficiency investment. **[106.1]** shows the trend of investment in energy conservation projects and energy intensity between 1980 and 2005.



106.1 **Investment in energy conservation & energy intensity (1980-2005)**

APERC 2008, Lin Jiang 2007

Although this investment data[e] is not comprehensive, particularly in later years when more avenues for energy conservation investment developed, the trend nevertheless reflects how economy-wide energy intensity changed over the same time period. With strong policy support and attractive financial incentives, energy intensity decreased rapidly at annualised rate of 4.5 percent between 1980 and 1995. Meanwhile energy conservation investment increased from CNY 1.5 billion (775 million real USD) in 1981 to CNY 14 billion (1.989 billion real USD) in 1995, an annualised growth rate of 17.6 percent. However, most of the financial incentives were cancelled or weakened following finance and taxation reform in 1994 and investment did not rebound until 1999. In 2003, the energy conservation investment reached CNY 23.5 billion (3.034 billion real USD), but actual energy intensity improvement had already decoupled as a result of rapid heavy industrialisation.

[e] *As reported in Lin Jiang 2007 from NBS data.*

STANDARDS AND TARGETS

[107.1] shows industrial energy consumption per physical unit of major product output and **[107.2]** energy efficiency indicators of major energy consuming equipment in the past alongside targets for 2010 and 2020 as outlined in the *Medium- and long-term energy conservation plan*. It is expected that energy consumption per unit of major products in 2010 will reach the early 1990s international level and further approach the advanced international level by 2020 (by 2010 for medium and large sized enterprises). Furthermore, the energy efficiency indicators of major energy consuming equipment are targeted to reach the advanced international level by 2010.

	UNIT	1980	1990	2000	2005	**2010**	**2020**
Comprehensive energy consumption per tonne of steel	kgce/tonne			906	760	730	700
Comparable energy per tonne of steel	kgce/tonne	1201	997	784	700	685	640
Comprehensive energy consumption of 10 types of non-ferrous metal	kgce/tonne			4809	4665	4595	4450
Comprehensive energy consumption of aluminum	kgce/tonne			9923	9595	9471	9220
Comprehensive energy consumption of copper	kgce/tonne			4707	4388	4256	4000
Energy consumption of unit energy factor of oil refining	kgoe/tonne factor			14	13	12	10
Comprehensive energy consumption of ethylene	kgce/tonne			848	700	650	600
Comprehensive energy consumption of large scaled synthetic ammonia	kgce/tonne	1431	1343	1372	1210	1140	1000
Comprehensive energy consumption of caustic soda	kgce/tonne			1553	1503	1400	1300
Comprehensive energy consumption of cement	kgce/tonne	219	201	181	159	148	129
Comprehensive energy consumption of plated glass	kgce/ weighting box			30	26	24	20
Comprehensive energy consumption of architectural ceramics	kgce/sq. meter			10.04	9.9	9.2	7.2

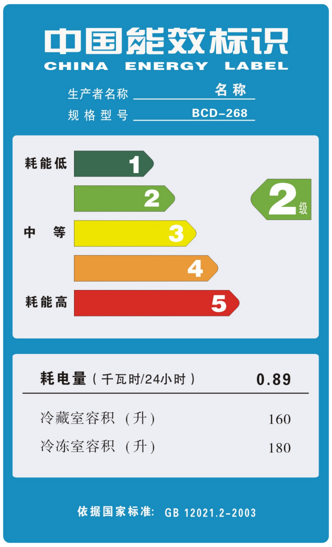
107.1 **Energy efficiency indicators and future targets for major industrial products (1980-2020)**

China Medium and Long Term Energy Conservation Plan 2004

	2000	**2010**
Coal-fired industrial boiler (under operation) %	65	70-80
Medium and small sized Motor (design) %	87	90-92
Fan (design) %	75	80-85
Pump (design) %	75-80	83-87
Air compressor (design) %	75	80-84
Room air conditioner (energy efficiency ratio)	2.4	3.2-4
Electric refrigerator (energy efficiency index)	80	62-50
Household gas cooker (thermal efficiency) %	55	60-65
Household gas water heater (thermal efficiency) %	80	90-95

107.2 **Energy efficiency targets for major energy consuming equipment (2000, 2010)**

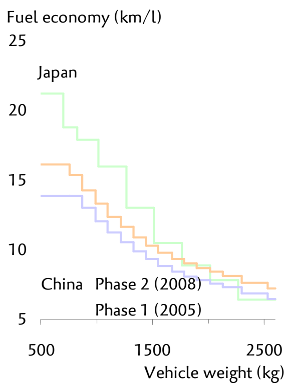
China Medium and Long Term Energy Conservation Plan 2004



108.1 Product efficiency label for household refridgerator

www.energylabel.gov.cn [in Chinese]

The refrigerator label, from top-to-bottom, gives the manufacturer name, ranks the comparative energy efficiency grade against other available products (lower grades indicating better performance), estimates kilowatt-hours of energy consumed per 24-hour period, and indicates refrigerator and freezer volumetric capacity.



108.2 Chinese and Japanese automobile fuel economy standards

APERC 2008, Feng and Sauer 2004

Chinese standards are for manual transmission vehicles. Standards are not normalised for variation in testing procedures.

End-user Products

For end-user products, central agencies have now promulgated twenty-four mandatory energy efficiency standards (EES) in five product categories and mandated an energy labelling system for four products. EES product categories include household appliances, lighting equipment, commercial equipment, industrial equipment, and vehicles.

Buildings

In the building sector, China currently has two sets of energy efficiency standards for residential and public buildings. However, enforcement of the standards has been problematic since their establishment because of narrow scope and lack of an effective administrative supervision system. Thus, a building inspection programme was launched by the central government in 2005 to monitor the implementation of such standards. Under the programme, if the developers and construction companies failed to comply with the regulations, they would lose their licenses or certificates.[f] Additionally, the *Civil building energy saving regulation*, issued in the same year, declared that "Construction units failing to meet the compulsory building energy saving standards shall be fined [CNY] 200,000-500,000." Despite such efforts, the effectiveness of these regulations at a local level and an appraisal and assessment mechanism under the inspection programme is still questionable. For example, effective supervision of real estate developers has been challenging, and building developers and even users capture little benefit from energy saving buildings as long as end user prices for electricity and city gas remain relatively low.

Passenger Vehicles

China has implemented ambitious fuel economy standards for passenger vehicles to help mitigate growing fuel consumption from automobile use. China has the world's second largest and fastest growing market for motor vehicles.

Fuel consumption limits for passenger cars (2004) outlined fuel economy standards for passenger vehicles, SUVs, and multipurpose vans in 16 weight classes (from less than 750 kilograms to over 2500 kilograms) and differentiated by transmission type. These standards were applied in two stages, first in 2005 and then in 2008 for new models and one year later for existing models.

Compared to fuel economy standards in other APEC economies, China's are more stringent overall than those in the US, Australia, and Canada, but not as stringent as in Japan.[g] Also, China's fuel economy standards are generally stricter for heavier vehicles so as to encourage the design and sale of smaller and lighter vehicles, an approach which may help to improve fleet-wide fuel economy. Future potential to improve vehicle efficiencies in China is still good, however, particularly for lighter vehicles, as illustrated by the more stringent Japanese fuel economy standards. **[108.2]**

And while such passenger vehicle fuel economy standards will be important for future growth in automobile ownership, commercial and heavy-duty vehicles currently consume a much larger share of petroleum than passenger vehicles. Considering this, there is good potential for further road vehicle efficiency improvements in freight transport.

[f] UNEP SBCI 2008

[g] An and Sauer 2004; Sauer and Wellington 2004

IMPLEMENTATION PROJECTS AND PROGRAMMES

The *Eleventh 5-year guidelines for energy development* emphasised ten key energy conservation projects covering the industrial, transport, building, residential, and commercial sectors. Over the guideline period, these projects are expected to save 280 million tonnes of oil-equivalent, accounting for almost four-fifths of the 20 percent energy intensity reduction target. The ten key projects are broad in scope and include the retrofit of coal-fired industrial boilers (kilns), district cogeneration, residual heat and pressure utilisation, petroleum savings and substitution, motor system energy savings, energy system optimisation, energy conservation in buildings, green lighting, government agency energy conservation, energy saving monitoring and testing, and development of technology service systems. In addition, over the guideline period, the government plans to close down inefficient industrial production units, including 100 million tonnes of steel production capacity and 550 million tonnes of iron production capacity.[h]

[h] UNEP SBCI 2008

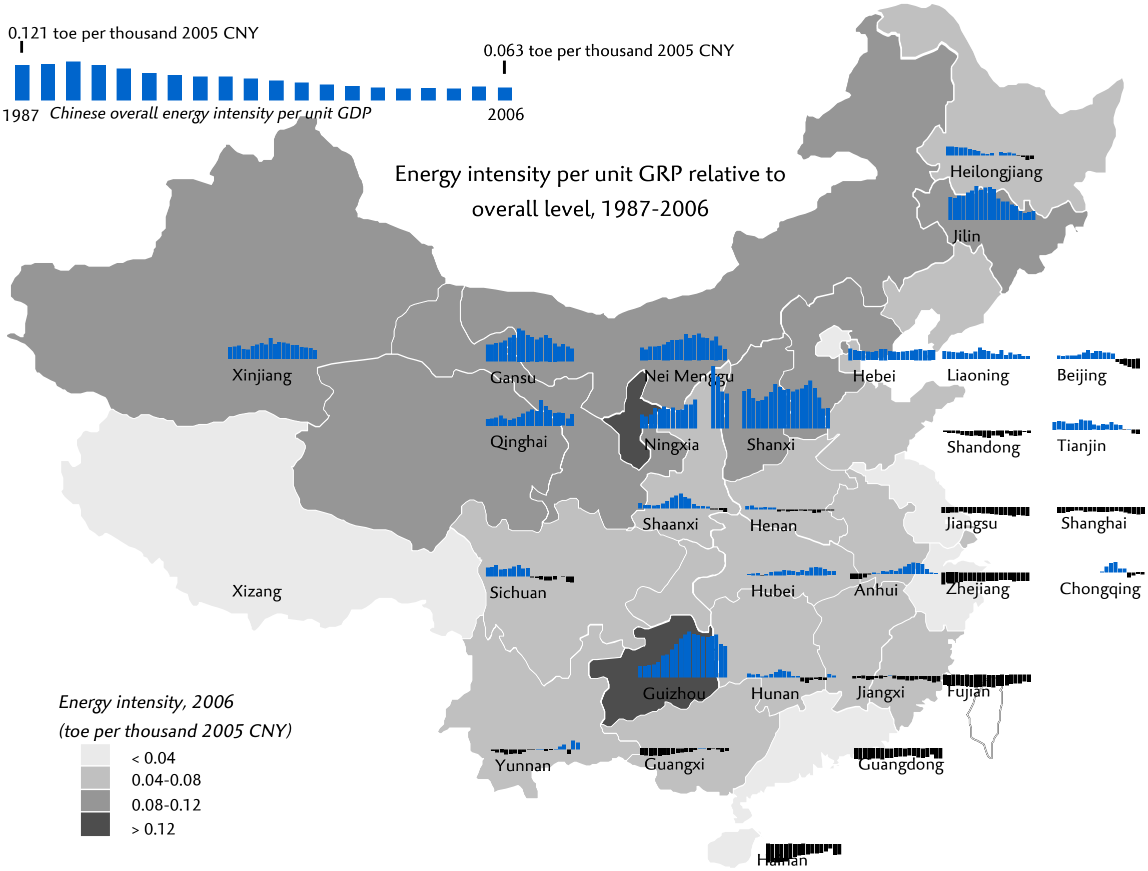
Besides the key energy conservation projects outlined in the *Eleventh 5-year guidelines*, the central government also launched various programmes aimed specifically at industrial sectors, buildings, and general public. For example, the *Top-1,000 enterprise energy efficiency action plan*, launched in September 2007 and led by the NDRC, targets energy saving of 50 million tonnes oil-equivalent by 2010. The 1,000 enterprises cover the nine major energy consuming industries including iron and steel, petroleum and petrochemicals, chemicals, power, non-ferrous metals, coal mining, construction materials, textiles, and paper. As the combined energy consumption of these nine industries accounted for 48 percent of industrial energy consumption and 30 percent of total energy consumption in 2005, they are expected to take the lead in improving energy consumption.

The building sector alone is expected to contribute 40 percent of the total energy saving target, with programmes to address both new and existing residential and public buildings.[i] New buildings are to be designed to fulfil a 50 percent energy saving standard, while a 65 percent standard is being implemented in several major cities such as Beijing and Tianjin. Existing buildings are to conduct energy saving retrofit programmes and incorporate urban reconstruction. Together, these measures are expected to improve 25 percent of total building area in large cities, 15 percent in medium cities, and 10 percent in small cities.

[i] UNEP SBCI 2008

Ordinary people in China have also been called to help save energy. In August 2007, the central government launched the *All actions to implement the comprehensive work plan for energy conservation and pollutant discharge reduction* campaign to emphasise the importance of lifestyle change, education, and adoption of new technologies. Programmes organised under the plan focus on communities, teenagers, enterprises, schools, and government bodies.[j]

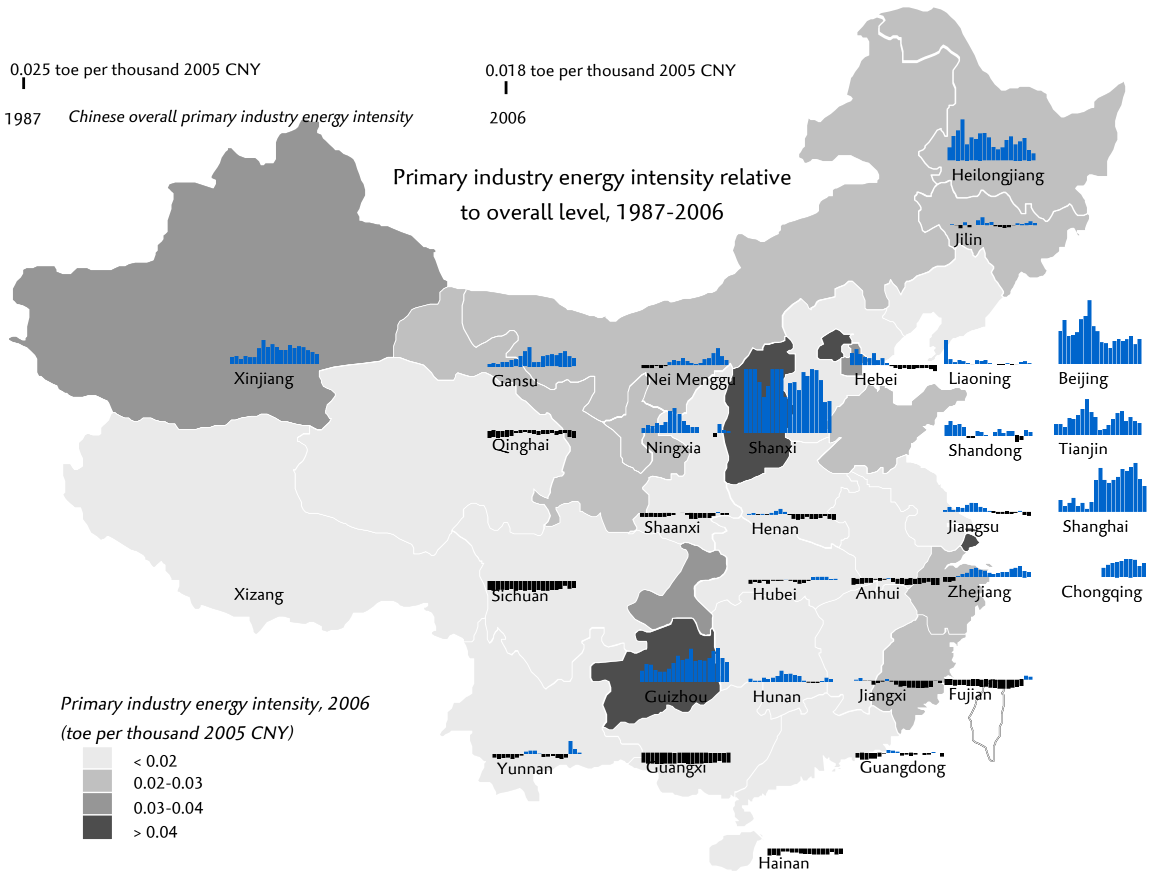
[j] The campaign was co-organised by 17 departments including the NDRC, Ministry of Finance, State Environmental Protection Administration, and State-owned Assets Supervision, and Administration Commission of the State Council.



110.1 **Economic energy intensity**

APERC 2008

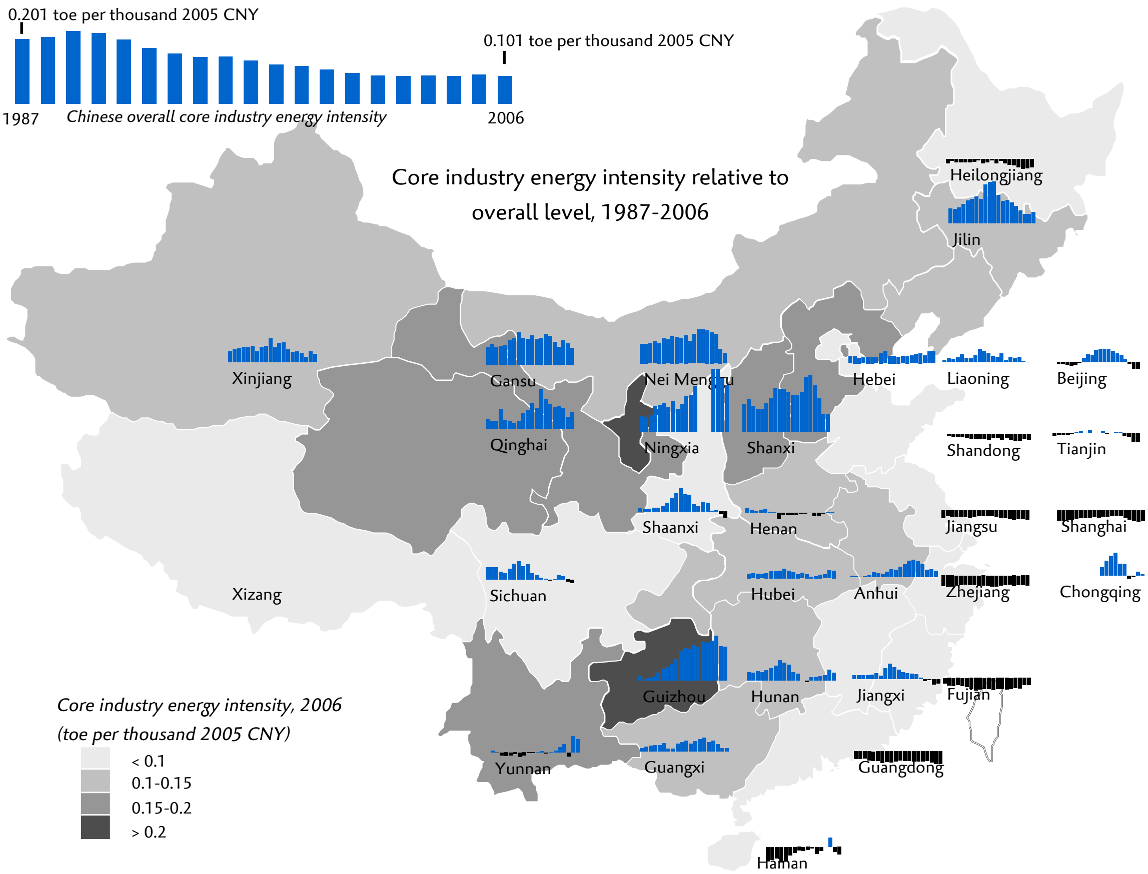
- Overall energy intensity in China fell dramatically from the late 1980s to the early part of this decade—from 0.121 toe per thousand 2005 CNY in 1987 to 0.063 in 2006—and was steady since.
- Regionally, total energy intensity was higher than average in the north and west, average in central China, and lower than average in the southeast.
- Though energy intensity in most provinces was generally similar to or just below the overall average since 1987, it was substantially higher in a few other areas; since about 2000, these relatively higher energy intensities have begun to decline, approaching economy average levels.
- The highest energy intensities are found in less developed areas including Guizhou and Ningxia.



111.1 **Primary industry energy intensity**

APERC 2008

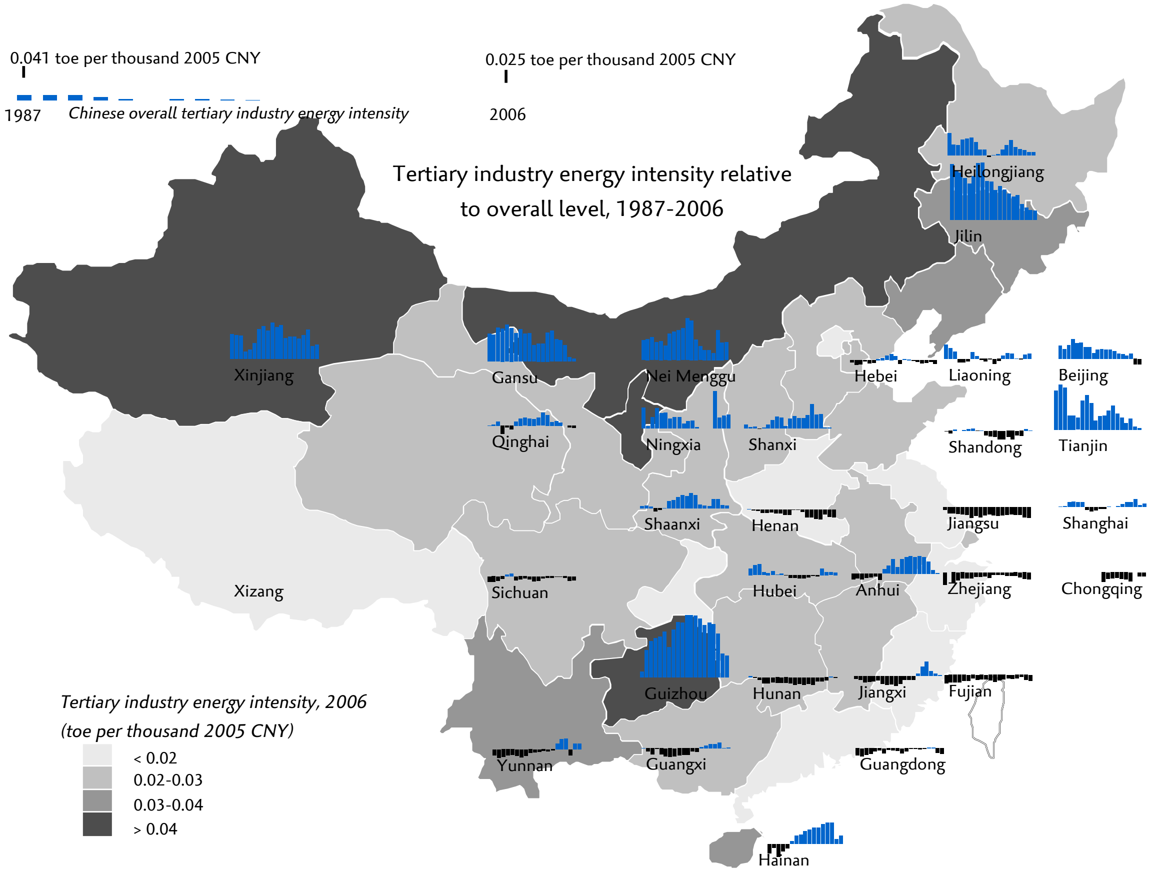
- Overall, primary industry energy intensity declined from 0.025 toe per thousand CNY in 1987 to 0.018 in 2006. The 2006 level for overall primary energy intensity was just 29 percent the total energy intensity level. [note: this figure for primary energy intensity, as with all other figures presented here, does not include estimations of the non-commercial energy consumption which is relatively more common in this sector, thereby likely under-representing "total" energy intensity]
- Regionally, primary industry energy intensity is geographically mixed. It was consistently relatively high in Guizhou, Shanxi, Heilongjiang, and urban areas and rarely exceptionally low in any one region. [note: urban primary industry intensities presented here may appear relatively high in part because farmers in these relatively developed areas might prefer commercial energy for activities which might rely on non-commercial or unreported fuel use elsewhere in rural China]
- The highest primary industry energy intensities are found in Guizhou and Shanxi while most other non-urban areas are relatively similar.



112.1 **Core industry energy intensity**

APERC 2008

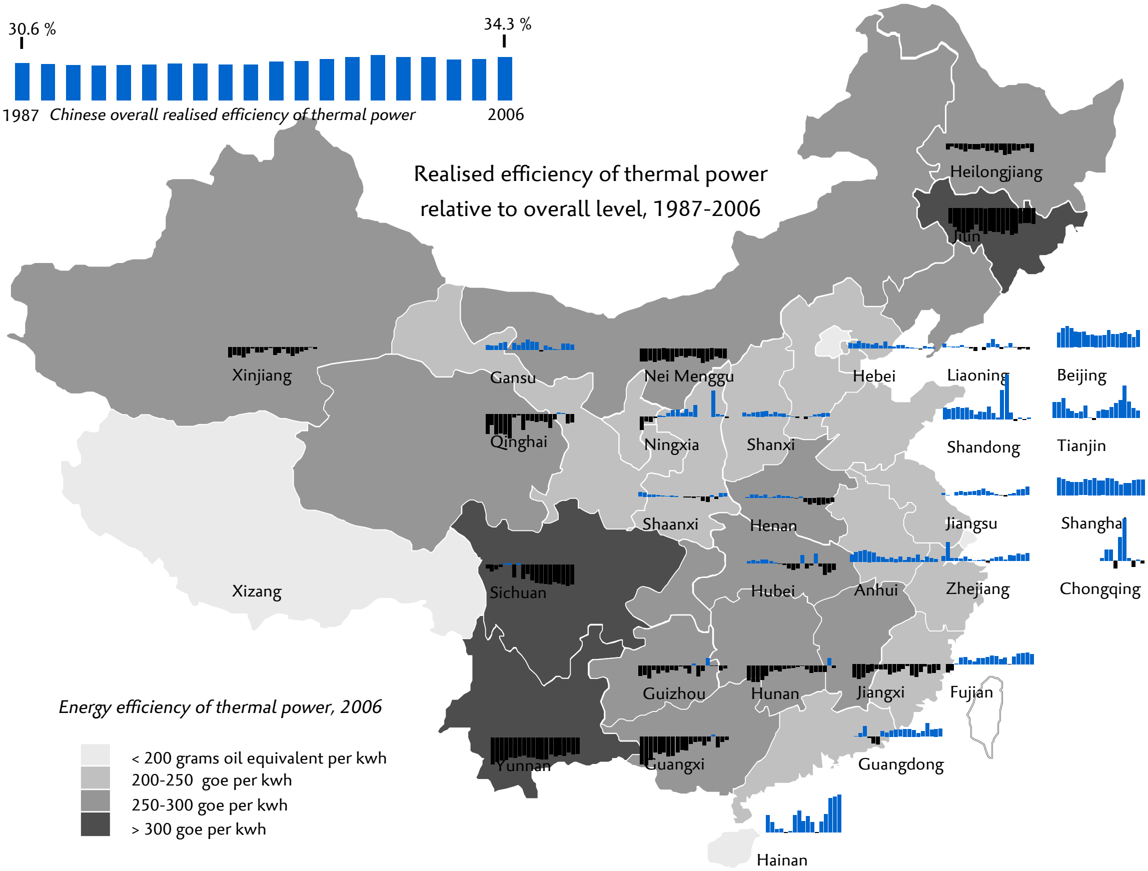
- Overall core industry energy intensity declined by half from 1987 to 2006— from 0.201 to 0.101 toe per thousand CNY— with a dramatic decrease following an initial rise through the late 1980s. Like overall intensity, core industry energy intensity stabilised following 2000, and its absolute level was approximately 60 percent higher than overall intensity in 2006.
- Regionally, trends for core industry energy intensity were relatively higher or relatively lower than the overall economy average in the same regions where total energy intensity trends were too.
- Core industry energy intensity is highest in Guizhou and Ningxia, where it still exceeds overall economy-wide averages for core industry energy intensity from 1987.



113.1 **Tertiary industry energy intensity**

APERC 2008

- Overall tertiary industry energy intensity declined from 0.041 toe per thousand CNY in 1987 to 0.025 in 2006. The 2006 level for tertiary industry intensity was 40 percent the total energy intensity level and just 25 percent the core industry intensity.
- Regionally, tertiary industry energy intensity was relatively higher or relatively lower than the overall economy average in the same regions where total energy intensity was too, but the shape of the trends and the magnitude of their relative differences varied.
- Tertiary industry energy intensity is highest in Guizhou, Ningxia, Nei Menggu, and Xinjiang, which in 2006 all exceeded the average overall level from 1987.



114.1 **Power generation efficiency**

APERC 2008

- Overall, efficiency of thermal power stations [note: thermal efficiency, including plant own-use but not transmission or distribution losses, calculated in the aggregate from energy equivalents of electricity leaving the plant divided by total fuel inputs] increased from 30.6 percent in 1987 to 34.3 percent in 2006. Stable from 1987 to 1996, overall aggregate efficiency rose quickly through the late 1990s and peaked at 35.7 percent in 2001 before dropping slightly through 2004 and rising yet again to 2006.
- Regionally, realised efficiency of thermal power was relatively higher than the economy average in the eastern coastal areas and lower in the northeast and southwest. The trends however are uneven, having dropped further below the average over time in Sichuan, converged up towards the average in Yunnan and Guangxi, and having remained stable in the northeast.
- Energy efficiency of thermal power is highest in Sichuan, Yunnan, and Jilin, where it exceeds 300 grams of oil equivalent per kilowatt-hour and lowest in Beijing, Shanghai, and Hainan.

URBANISATION AND ENERGY USE

At the outset of the reform period in 1978, the Chinese economy and its energy demand was dominated by energy intensive state-owned heavy industry. Secondary industry, as a whole, generated 48 percent of total GDP.[a] However, benefiting from China's comparative advantages in human capital, light industry grew quickly through the year 2000 in the form of local TVEs and private enterprise. As the share of light industry relative to heavy industry in China's economic output increased alongside technological improvements in energy efficiency, the energy intensity of the industrial sector as whole declined precipitously.[b] This decline continued until approximately 2001, when improved profitability, access to capital, and incentive structures made entry into heavy industry attractive to local governments and other investors. Since then, heavy industry has unexpectedly returned to once again dominate economic output and energy consumption. Today, industry accounts for 49 percent of GDP[c], with heavy industry reaching about 70 percent of industrial output value. Investment-led growth in the industrial sector is clearly the most important factor driving current growth in Chinese energy use.

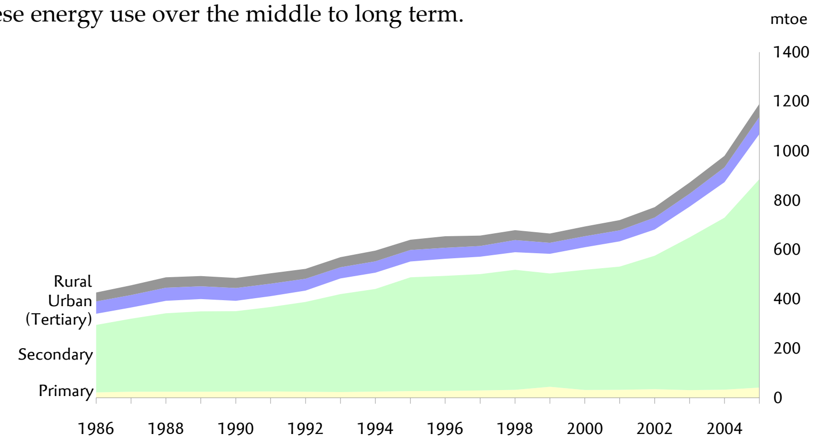
[a] *NBS 2008*

[b] *See "Energy efficiency" section of this report.*

[c] *Share for all secondary industry in 2006.*

This new growth in heavy industry since 2000 has delayed the expected transition in Chinese energy use from industry to the residential sector. In fact, total residential energy use in both rural and urban areas was relatively flat or even in decline from 1986 to 2002 before beginning to climb in the period since.[d] So even though Chinese income and urbanisation levels have risen rapidly, the associated incremental growth in residential energy use since 2002 has largely been additional to, rather than displacing, growth in heavy industrial energy use. That is, on its own, growth in Chinese residential energy use as a result of rising incomes and urbanisation since 2002 is significant; alongside the even more dramatic growth in industrial energy use, however, its import appears diminished. Nevertheless, given the expansion in number and consumptive power of an urban middle class, the residential and commercial sectors can be expected to gradually change the character of Chinese energy use over the middle to long term.

[d] *This decline can be attributed in part to the decline in the share of residential energy use taken by coal.*



115.1 **China final energy consumption by sector (1986-2005)**

APERC 2008

Urbanisation is important to understanding how this shift will occur. Urbanisation in China is tied up with growth in income and expenditure, decline in family size, and heightened demands for quality of life— that is, the development of a middle class. From an energy use perspective, urbanisation in China does now and will continue to mean for the residential and commercial sectors more demand in each household for convenient, high quality, and clean fuels such as electricity and LPG (along with the infrastructure to supply those fuels and the appliances to convert them into useful services) and less demand for coal.

Three things are clear: (1) the Chinese urban population is rapidly increasing; (2) an urban household spends more and increases that spending more than a rural household over each year; (3) an urban household raises its consumption of clean fuels and lowers its consumption of dirty fuels over each year. The developmental direction is set. And so far, these trends mirror economic and energy development experience from elsewhere in APEC. The timing and magnitude of these changes, however, will be unique to Chinese conditions and will depend on the economic, political, and lifestyle developments which are now taking shape.

PATTERNS OF URBANISATION

As of 2006, the Chinese population was 43.9 percent urban (577 million persons) and 56.1 percent rural (737 million persons)[e], and the total urban population increased by 14.9 million in 2005 alone[f], compared to a net annual loss of 8.0 million from rural areas. By 2030 the split is forecast to rise to 60.3 percent urban (880 million persons) and 29.7 percent rural (579 million persons).[g]

Urban population growth generally occurs through three routes; in China, migration from rural to existing urban areas is the most significant driver of urban population growth, followed next by geographic expansion of urban boundaries over existing rural populations, and least importantly by natural growth of an existing urban population.[h] Through the early reform period, the majority of Chinese urban migration was intra-provincial.[i] More recently, however, from the mid 1990s as migration controls began to ease, spectacularly visible inter-provincial migration was witnessed through the growth of urban mega-regions along the eastern seaboard including The Bohai Bay Rim (Beijing, Tianjin), The Yangtze River Delta (Shanghai, Hangzhou, Nanjing), and the Pearl River Delta (Guangzhou, Shenzhen, Zhuhai). Current central government policy, however, seeks to slow such inter-provincial migration into these top-tier cities in favour of more localised in-province aggregation into provincial capitals, midsized economic centres, or even county seats.[j] The continued rate of such urban migration will be a factor of both urban area government policy and the relative economic opportunity afforded by an urban life.

From a policy perspective, the geographically-specified household registration, or *hukou*, system limits a family's ability to move from a rural to an urban area. Such registration is necessary to receive basic public services such as schooling and medical care. But because re-registration from a rural to urban status is not freely available to many

[e] *According to a population density rather than administrative measure.*

[f] *NBS 2008*

[g] *UN 2007*

[h] *World Bank 2008*

[i] *Henderson 2007*

[j] *Geographic discussions of Chinese urban development often refer to urban areas as belonging to one of several sets of "tiers", with the largest, wealthiest, and most developed costal urban agglomerations making up the first tier, followed by other groupings of consecutively smaller and less developed, interior cities and towns – for example, see McKinsey Global Institute 2008.*

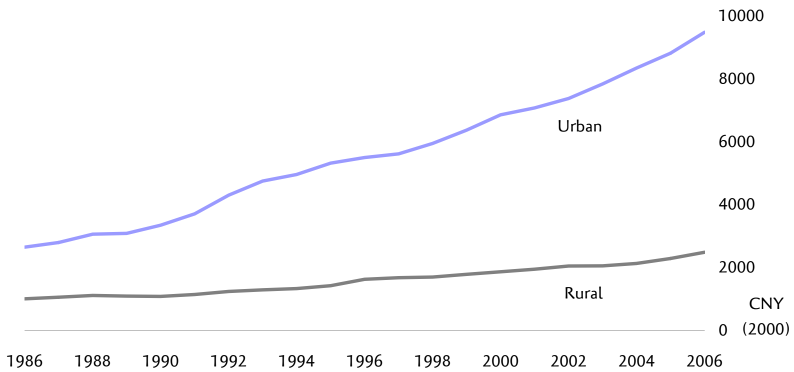
prospective migrants, this serves as a deterrent to urban migration. However, as the role of the state has declined through the reform period in providing vital services for people's daily lives, this obstacle, in turn, has declined in importance. Incremental relaxation of this system through policy reform, in addition to more radical policy tools such as reform of rural land ownership, could open a steady stream of continued urban migration to the areas of policy makers' choice.

The economic forces driving urban migration in China are less fine-tuneable. The statistics are stark. Average urban household expenditure in 2006 was 3.64 times more than rural expenditure.[k] To a potential urban migrant, the potential for upward economic mobility by even capturing a small share of that average would seem huge. Moreover, this wealth disparity[l] makes migration even more attractive year after year— over 2002-2006, urban household expenditure growth averaged 8.7 percent annual growth, compared to 5.3 percent annual growth in rural areas[m]. And while growth in income and expenditure is an important driver of residential energy demand growth, other aspects of urbanisation present today in China also influence the speed and nature of that growth.

[k] *As reported by NBS and uncorrected for price differences between urban and rural areas – for more on this issue, see World Bank 2008.*

[l] *As measured by expenditure.*

[m] *At constant CNY; NBS 2008*



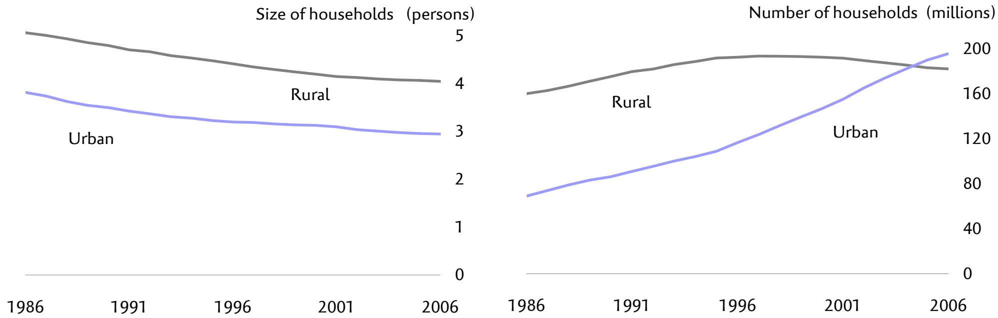
117.1 **Household expenditure (1986-2006)**

APERC 2008

One important issue is household size. Urban households in China have been steadily decreasing in size over the past 20 years and have fewer members on average than rural households—urban average household size was 2.95 compared to 4.05 in rural areas in 2006, though the decline now appears to be levelling off. This trend, which is common among an urbanising population, has been observed elsewhere in APEC to increase per capita energy consumption in the residential sector.[n]

[n] *Liu et al. 2003; Zhou et al. 2003*

A declining household size in urban areas, along with urban population growth itself and rural population decline, has also led to urban households now outnumbering rural households in China. Absolute rural population is still smaller than the rural population, but on a household basis, China has already become an urban society.



118.1,2 **Household size & number (1986-2006)**

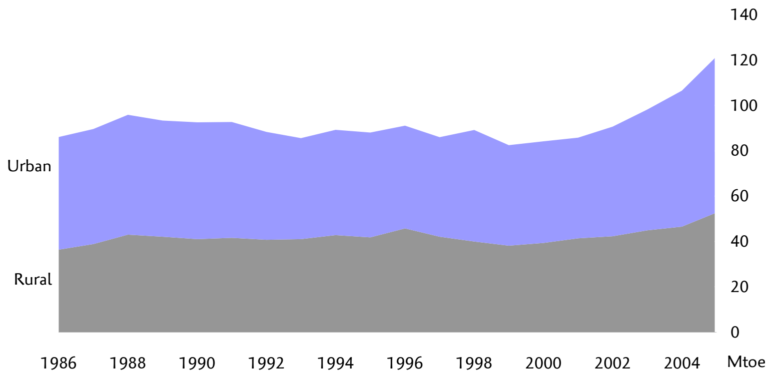
APERC 2008

EFFECTS ON RESIDENTIAL ENERGY USE

It is worth repeating the very small share of total final energy consumption taken by the residential sector in China, particularly in comparison to the dominant industrial sector. In 2005, the residential sector was only 10.2 percent of final energy consumption (and only 5.7 percent for urban residents).[o] But though the share is quite small today, it is clear from developmental experience elsewhere in APEC that the importance of urban residential final energy consumption will increase over the middle to long term, making it worthwhile to consider now. Historical trends are illuminating.

[o] *APERC database 2008*

Since the mid 1980s, total residential energy use in China (both urban and rural) was relatively flat, despite income growth, before seeing a sharp upturn around 2002.

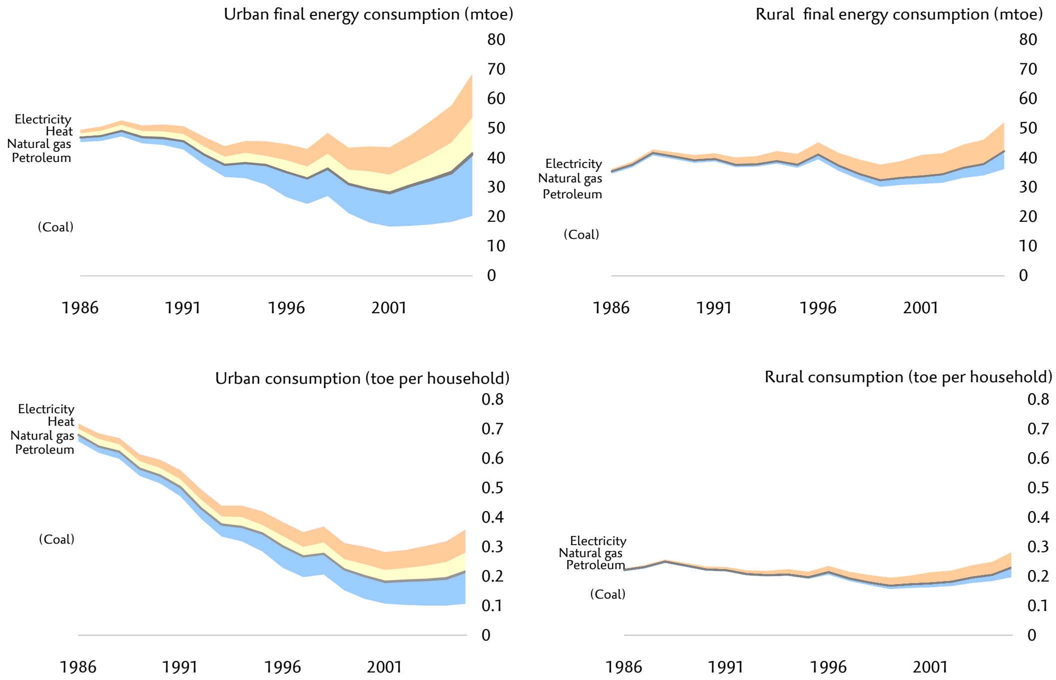


118.3 **Final residential energy consumption (1986-2005)**

APERC 2008

Over this period of rapid economic growth, during which rural expenditures have more than doubled as shown in **[117.1]**, both total and household rural residential energy use has nevertheless been relatively flat. Coal use has declined slightly, displaced only gradually by incremental electricity and LPG use.[p]

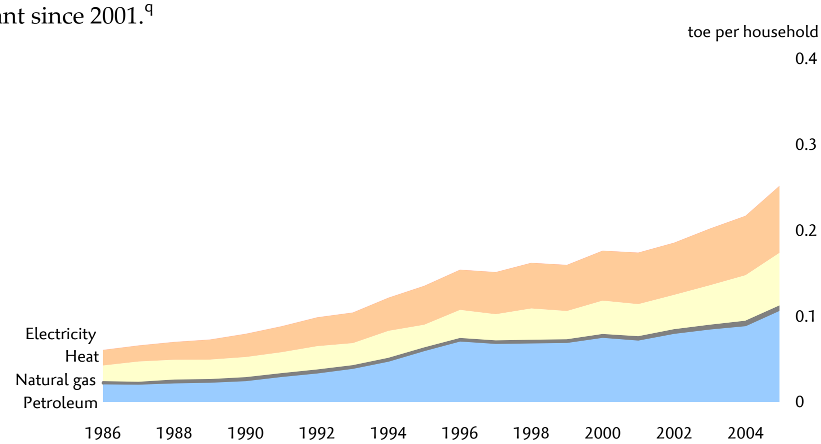
[p] *The statistical consistency of rural residential coal use has been questioned. See Sinton and Fridley 2001. It is possible, for example, that rural residential coal use in the early years of this time series was underreported relative to current figures.*



119.1,2,3,4 **Urban & rural final energy consumption, total & per household (1986-2005)**

APERC 2008

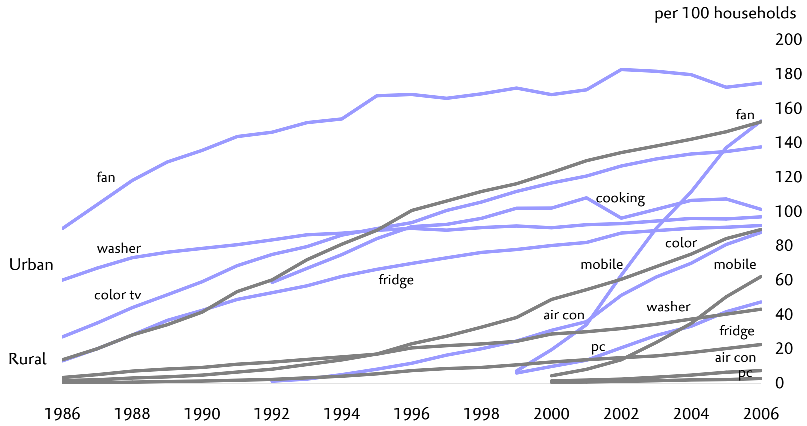
Urban households, however, have had a more significant transition in both total final energy consumption and fuel choice over the past 20 years. Urban households, on average, have greatly reduced their use of coal and increased their use of LPG, centralised heat, and electricity. In doing so, final energy consumption on a household basis dropped sharply until approximately 2001, at which point declines in coal use stabilised and incremental rapid growth in cleaner fuel use contributed to gradual growth on a household basis. And considering the decline in urban household size and the rapid overall urban population growth described above, growth in aggregate urban residential energy use has been somewhat more significant since 2001.[q]



119.5 **Urban final energy consumption per household, excluding coal (1986-2005)**

APERC 2008

Differences in home appliance ownership over the past two decades mirrors this disparity in energy composition and use between urban and rural households. A symbol of modern development, appliance ownership has grown rapidly throughout China over the reform period, and fastest of all in urban areas. Urban households own more and a wider variety of appliances than rural households. Urbanisation has clearly become the defining factor for residential energy use patterns in China.



120.1 **Electric appliance ownership (1986-2006)**

APERC 2008

[q] *Chinese statistical conventions have traditionally held a narrow definition of the transportation sector, so that it largely applies to energy used by enterprises whose primary function is transportation, such as freight services or air travel. The significant petroleum use indicated for the residential sector, therefore, include gasoline and diesel typically used in automobiles or other vehicles for personal mobility alongside other "true" residential petroleum products such as LPG (though even LPG can be used for transport demand). Similarly, freight transportation of finished manufactured goods is often included as a secondary industry energy consumption within the subsector under which the consuming enterprise is primarily classified, such as steel. Therefore, according to more commonly used international sectoral definitions, the approximate 36 percent of the urban and 40 percent of the rural petroleum use depicted in these figures (2005 data) which are attributed to combined gasoline and diesel consumption should largely be disregarded; see Sinton and Fridley 2001 for more.*

Growth in urban residential clean energy demand is driven by five main household needs: home heating, cooling, cooking, lighting, and entertainment. For some of these needs, such as heating and cooling, the amount and type of energy needed to meet these needs varies widely among Chinese urban areas according to climate, wealth, and resource access. For other needs, such as cooking, lighting, and entertainment, regional variation is more narrow.

Systematic household surveys undertaken in 1999[r] describe such variation as reported directly by urban residents. Across the five cities investigated— Shenyang, Beijing, Shanghai, Yixing, Guangzhou— Beijing's households used the most total energy, about twice as much on average as those in Shenyang, where households used the least residential energy on average. Some of Beijing's high total energy use in this survey was due to extensive coal consumption, which represented 35 percent of all Beijing household energy use, as opposed to 10 percent in the poorer, yet colder, Shenyang[s], along with three times as much natural gas consumption. None of the other sampled cities, all with significantly warmer climates than Beijing and Shenyang, reported coal or natural gas use. Instead, these more southern households reported higher average LPG or town gas[t] and electricity use.

Electricity ranged between 38-75 percent of total urban household energy use among the five cities, with end use ranked as follows: refrigeration, air conditioning, lighting, television, rice cooker, and home electronics. Electricity use for refrigeration, on average the number one draw in each household, was quite similar among the included cities (surveyed households generally owned one unit), suggesting broad potential to affect this important usage through technology improvements. Electricity demand for air conditioning varied greatly by climate zone, from approximately 1 percent of total electricity demand in Shenyang (8 percent ownership, average temperature 9.7 degrees) to 18 percent in Beijing (61 percent ownership, average temperature 13.1 degrees) and 32 percent in Guangzhou (88 percent ownership, average temperature 22.8 degrees). Lighting electricity use varied largely as a function of CFL penetration and use, demonstrating the leverage of spreading this technology, as well as by floor space. Television electricity use and ownership levels, like that of refrigeration, was similar across cities. Rice cookers, used almost daily in most cities outside Beijing, averaged about 9 percent of household energy use, suggesting that this appliance category is an important target for efficiency standards, while other home electronics drew only 3-10 percent of household electricity.

Gas use, primarily for home heating (in colder climates), cooking, and water heating, varied based on access. At the time of the survey, natural gas was only available in two cities, Shenyang and Beijing, where it accounted for 10-15 percent of total household energy and was used alongside LPG. Town (here, coal) gas had only marginal penetration outside of Shanghai, where it accounted for 36 percent of total energy use, though in the years since this lower-calorific fuel has been displaced by natural gas as access and supply has increased in that market (for example, in Shanghai). LPG use was most significant in the two cities lacking both town and natural gas infrastructure, Yixing (36 percent of total energy) and Guangzhou (19 percent).

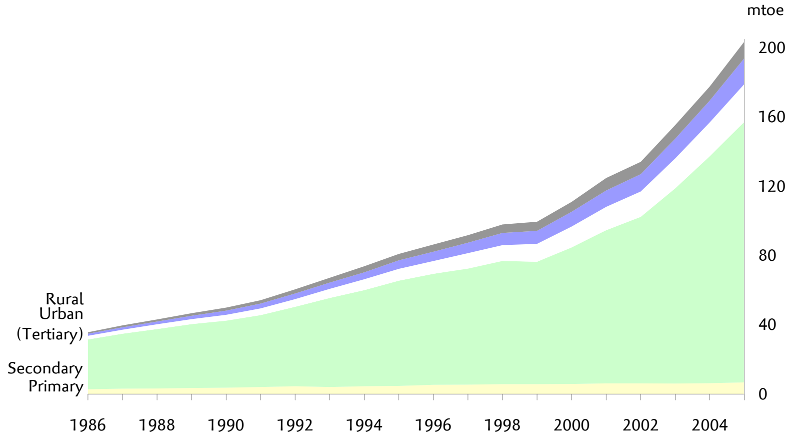
Despite rapid growth since 2001, residential energy use in Chinese urban areas is still low given income levels relative to other APEC areas. For example, in Shanghai, one of the richest, most developed urban areas in China, urban residential electricity use per household in 2006 was about 1800 kilowatt-hours, just over 16 percent the US average[u]. Energy-conserving consumer behaviour is likely responsible for some of this difference, and this highlights the importance of preserving such behaviour into the future.

[r] *Brockett et al. 2002*

[s] *Most of the surveyed households in Beijing who reported coal use were not attached to central heating systems – the energy inputs for these heat systems were not counted as part of the C-RECS survey.*

[t] *Used primarily for cooking and water heating.*

[u] *EIA 2008*



121.1 **Final electricity consumption by sector (1986-2005)**

APERC 2008

SUSTAINABLE URBAN TRANSPORT – THE CASE OF XI'AN

Continued urbanisation poses a transport challenge to Chinese cities. Growing urban income, combined with insufficient urban mass transit infrastructure, has driven motorisation trends. Moreover, the speed of road construction has not kept pace with that of motorisation. Unless appropriate transport measures are taken, this trend may result in heavier traffic congestion, higher energy needs, and greater air pollutant emissions.

To help support the smooth and efficient transport of their urban populations, thirty cities in China with population exceeding 1 million are either planning or developing new mass transit infrastructure, namely heavy rails and subways. [People's Daily 2005] Until recently, urban planners in Chinese cities have generally preferred a "wider is better approach" when designing transport corridors. [personal communication 2007] However, as sustainable development and energy conservation have become priorities, particularly in the *Eleventh 5-year guidelines*, there has been a major policy shift in recent years for Chinese cities to promote sustainable transport development.

Out of a number of cities in China, Xi'an offers an interesting case with respect to sustainable transport development. [note: Xi'an has a population of 3.12 million in an urban core of area 203 square kilometres] The city has eased congestion and air quality problems by implementing various transport measures. For example, since 2000, no motorbikes have been allowed within the second ring road, and during the day-time, no trucks as well. In addition, the bus service has been improved substantially, with the total route length increased by 3.5 times between 1994 and 2003 and mostly operated by CNG-powered buses. [Chen Kuanmin and Mao Zhongan 2004] To encourage the use of buses, an IC card fare system was introduced in 2007, and IC card holders can enjoy up to 50 percent reduced fare.

As a long-term transport option, the city plans to develop six subway lines, the first of which will be completed in 2011. Coordination among various government agencies – *at municipal level*, and *between central-municipal level* - is a key issue for the implementation of subway projects. For example, in Xi'an, there are eight governmental organisations with duties related to urban transport development, and their responsibilities and priorities are different. As a means to enhance inter-agency coordination at the municipal level, the city has formed issue-specific committees in which vice-mayors representing each agency resolve the conflicts of interest. Also, over the past decade, the central government has increased consultations with municipal government when transport regulations and policies are developed.

The case of Xi'an offers the important lesson that comprehensive measures – including regulation on road transport and development of infrastructure for buses and subways – need to be implemented for sustainable urban transport development. It also highlights the impact of concerted efforts at both municipal level and central government level to develop a transport system that can smoothly and efficiently handle the increasing need for urban passenger transport.

122.1 **Municipal agencies related to urban transport in Xi'an**

Wang Yuanqing 2005

IMPLICATIONS OF URBAN RESIDENTIAL ENERGY USE

And although the energy use of the residential sector itself is small compared to the Chinese industrial sector or even other APEC economies, this does not make it insignificant. The emergence of a middle class in China has already profoundly influenced the nature of broader economic and energy development outside of this narrowly-defined sector. The effect of this influence on economic structural change, however, is not straightforward.

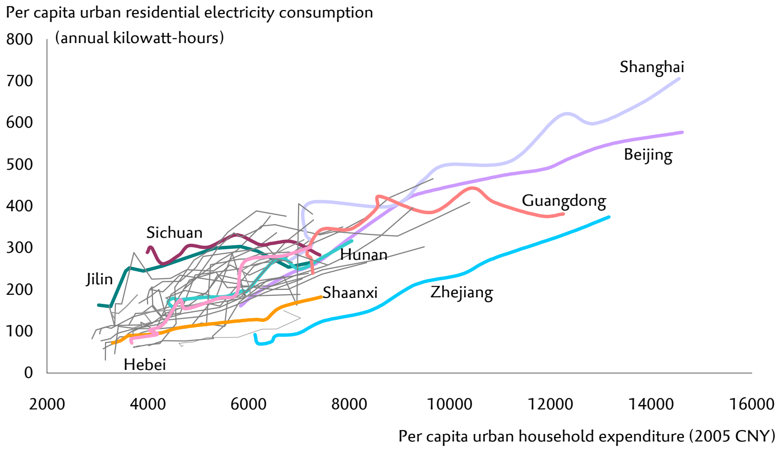
From one perspective, urbanisation and the associated demand for residential and commercial floor space is a direct driver of industrial activity, such as construction, and indirectly even other heavy-industrial activity, such as steel, cement, and glass production. More broadly, this associated urban energy demand growth supports a narrative of rising domestic middle class purchasing power and an economy-wide recalibration to meet such domestic-driven demand. Growing urban middle class expenditure will be key to sustaining China's economic transformation, and in turn, energy demand, in the middle to long term. In the short to middle term, however, it is clear that urban infrastructure is contributing to energy demand growth in Chinese industry. And of course, per capita transportation demand and energy use for both personal mobility and freight increases dramatically with urbanisation as well.

Considering other factors, however, the urbanisation-driven development of the commercial and services industry in China has the longer-term potential to moderate Chinese energy demand growth.[v] The growth of urban services such as restaurants, entertainment complexes, schools and hospitals, and public transportation are tightly linked with rapidly rising urban residential expenditures. And though overall, commercial sector development certainly demands significant new energy resources, particularly relatively clean fuels such as electricity or natural gas, this increasing commercial energy demand is not purely incremental; increasing prevalence of restaurants, for example, which are more likely to use cleaner and more efficient cooking fuels such as LPG, have likely accelerated the decline in energy-intensive coal use among urban households through the reform period. Far more significantly, though, on the supply-side, urban residents are more likely to work in service-sector or light-industry jobs. This creates more economic value using fewer direct energy resources than heavy industry or even smaller-scale rural enterprises. From this perspective, urbanisation will be actually be a key element in achieving the structural economic shifts that the central government has prescribed to achieve its ambitious energy intensity targets. Overall economic well-being, and hence total energy use, will no doubt rise in China as result of urbanisation, but urbanisation will also ultimately provide the economic framework to moderate and even green Chinese energy consumption.

[v] *This sector roughly corresponds to the "tertiary industry" designation used in official Chinese statistics.*

Urban lifestyle choice will be a key factor in reconciling these two perspectives on urban development and energy use. As described above, current trends give cause for both promise (such as the relatively low electricity use per households a given income level) and slight concern (declining household size, for example, though this is certainly typical).

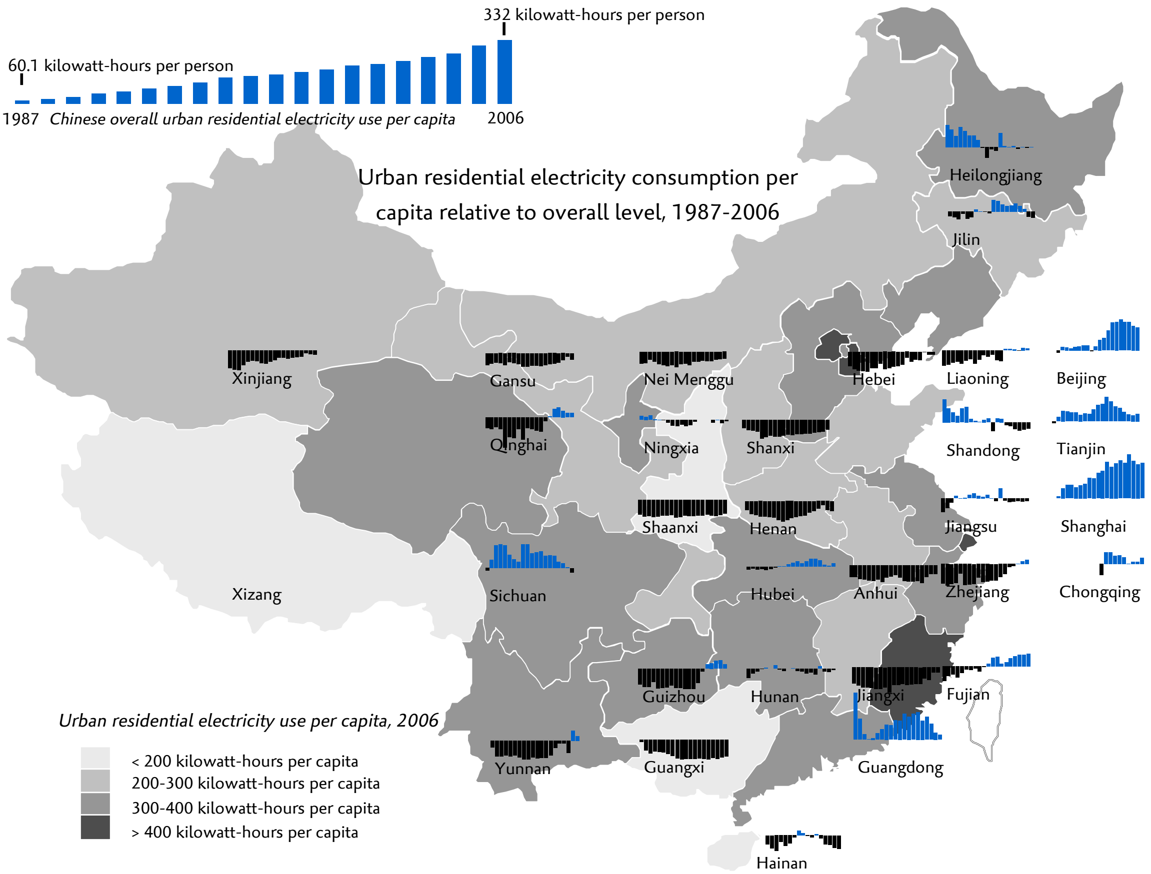
In recent years certainly, urban household consumption growth for clean fuels (electricity, 6.2 percent annualised growth from 2000-2005) has been coupled with urban household economic development (expenditure, 5.2 percent annualised growth 2000-2005). And though the relationship between household development and clean energy use varies among different parts of China, the overall direction is clear and does not seem to be substantially slowing over time.



124.1 **Per capita urban electricity consumption vs. expenditure (1995-2006)**

APERC 2008, China Statistical Yearbooks (1996-2007)

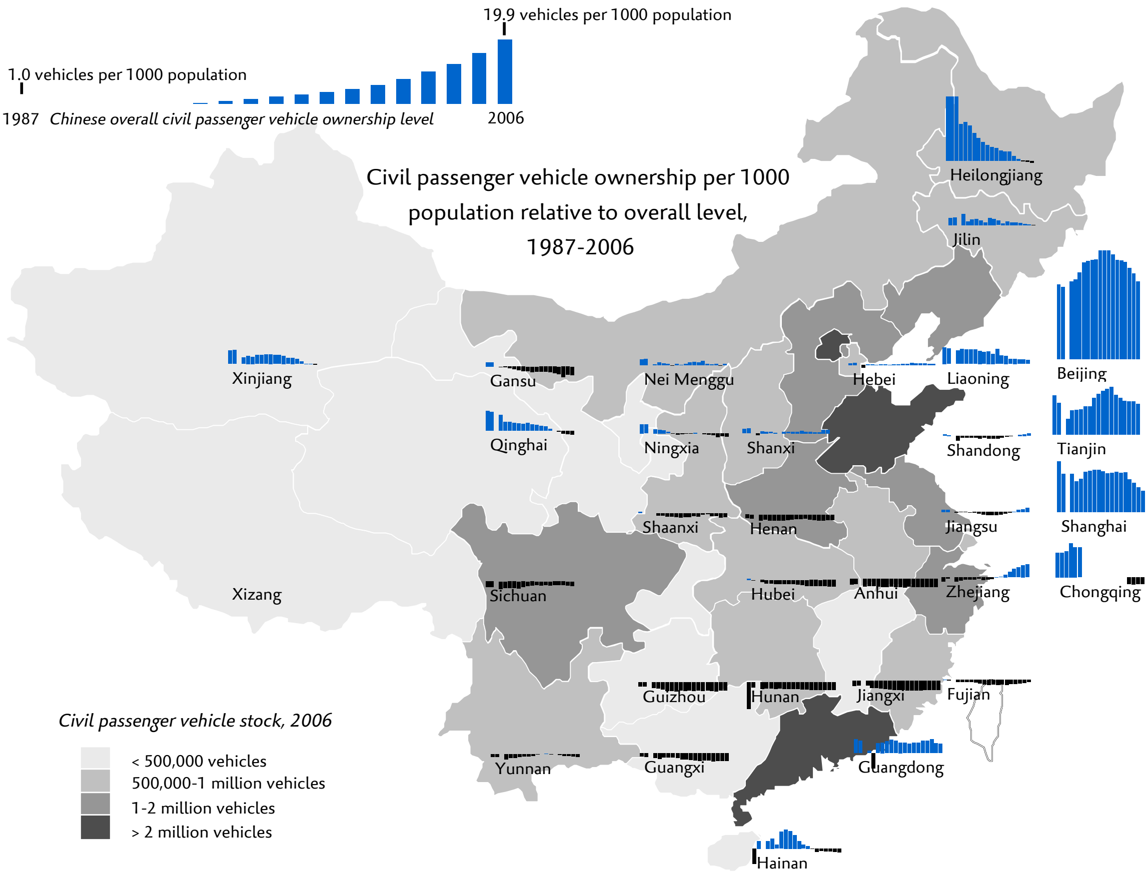
From past trends then, it is reasonable to think that incremental Chinese urban energy use will grow alongside economic development. The final extent of this growth, however, is not yet decided. This will be the impact of lifestyle decisions. As **[124.1]** shows, Chinese urban development still has a great store of potential, and the lifestyle frontier is just now being tested by those most advanced urban areas. Now is an important moment. If Shanghai, Beijing, Guangdong, Zhejiang, and their peers can successfully implement sustainable urban lifestyles, the rest will follow, to the great benefit of the Chinese people. If not, not.



125.1 **Urban residential electricity use**

APERC 2008

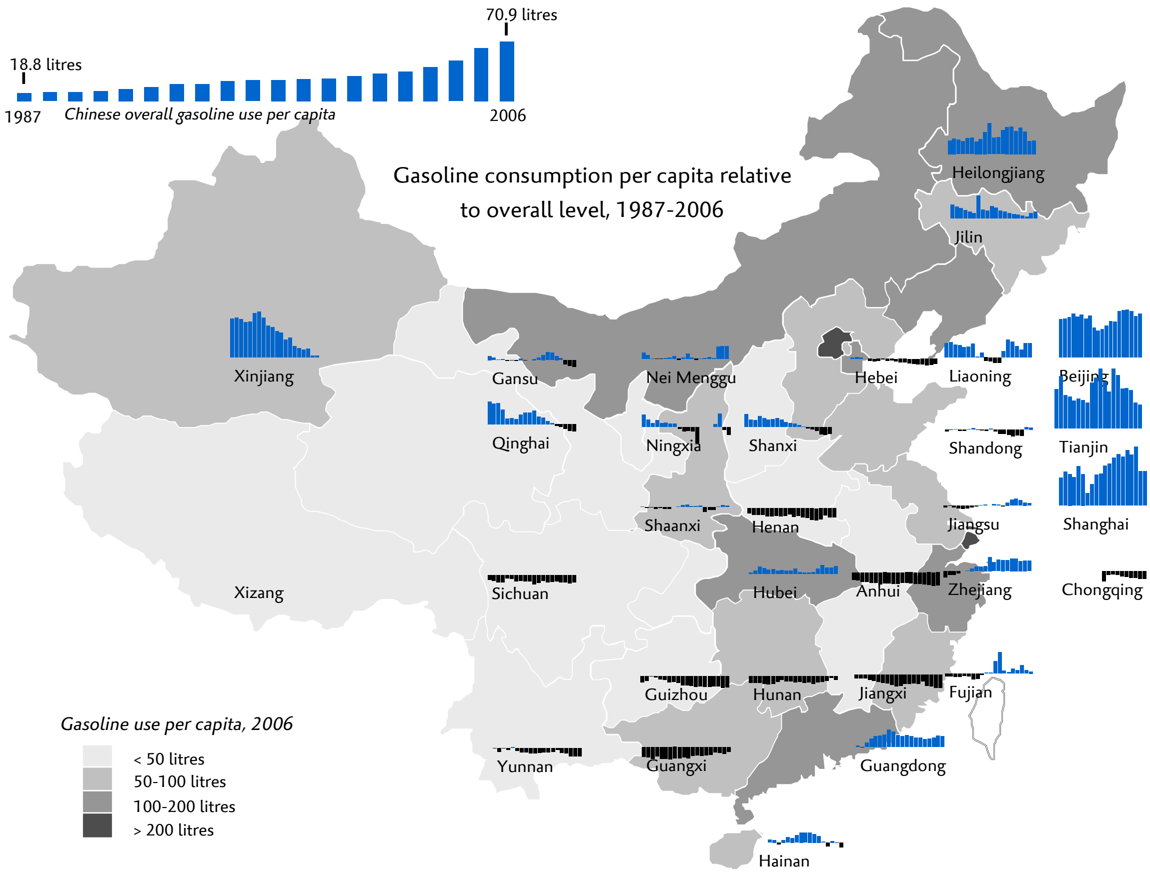
- Overall, urban residential electricity use per capita rose gradually from 60.1 kilowatt-hours in 1987 to 332 kilowatt-hours in 2006.
- Regionally, urban residential electricity consumption per capita was relatively higher in the most developed urban areas such as Beijing, Shanghai, and Guangdong, but also in Sichuan. Relatively higher consumption in these areas, however, seems to have peaked after about 2000, as per capita electricity use in relatively low consumption urban areas elsewhere in China converged up towards the overall average level.
- Urban residential electricity use per capita is highest in Beijing, Tianjin, Shanghai, and Fujian, where it is at least twice the level in Shaanxi and Guangxi. Many other areas have similar consumption levels.



126.1 **Passenger vehicle ownership**

APERC 2008

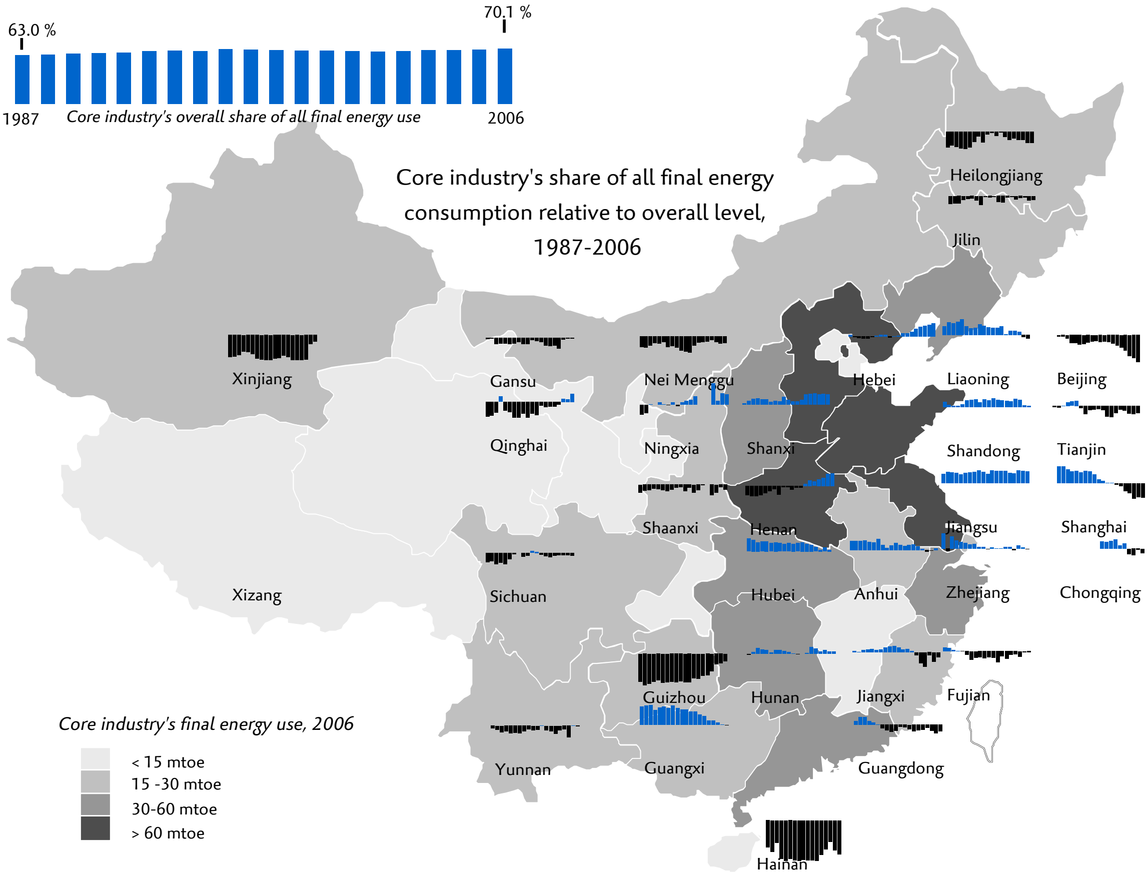
- Overall, civil passenger vehicle ownership levels rose with nearly constant acceleration from 1.0 vehicles per 1000 population in 1987 to 19.9 vehicles in 2006.
- Regionally, vehicle ownership levels were significantly higher than elsewhere in China in Beijing, Tianjin, and Shanghai but converged down somewhat towards economy averages from the late 1990s [note: the downturn in relative vehicle ownership levels in Shanghai post 2000 and complimentary increase in Zhejiang may be due in part to Shanghai residents registering vehicles outside of the city]. Provinces in the northeast, which had vehicle ownership levels initially higher than the economy average in the late 1980s and early 1990s, also converged down towards the economy average. Guangdong province remained consistently above the average.
- The total civil passenger vehicle stock, uncorrected by population, is highest in Guangdong, where it exceeds 3 million, followed by Beijing and Shandong, where it exceed 2 million. Variation is wide; Fujian, which neighbours Guangdong, has only about one-fifth as many registered vehicles, and Jiangxi just over one-tenth as many.



127.1 **Gasoline use per capita**

APERC 2008

- Overall gasoline use per capita rose with gradual acceleration from 18.8 litres in 1987 to 70.9 litres in 2006.
- Regionally, gasoline consumption per capita was relatively low in southwest and central China, while consistently higher than average along the developed coast and in the oil-rich northeast.
- Gasoline use per capita is highest in the most urbanised regions, such as Beijing and Shanghai, where it exceeds 200 litres annually.



128.1 **Core industry energy use**

APERC 2008

- Overall, the share of all final energy consumption taken by core industry rose from 63.0 percent in 1987 to 70.1 percent in 2006.
- Regionally, core industry captured a relatively higher share of total final energy consumption in central China and the eastern coastal region between Zhejiang and Liaoning. In developed urban areas such as Beijing, Tianjin, and Shanghai, the share of energy used by core industry declined relative to the overall average through the period.
- Core industry uses the highest total amount of energy in Hebei, Henan, Shandong, and Jiangsu, each exceeding 60 million tonnes oil equivalent.

CHINA'S AIR

Energy consumption is vital to China's industrialisation and economic progress. With energy consumption, however, comes a multitude of environmental issues. A particularly severe concern in China is the emission of air pollutants from combustion of fossil fuels, especially coal. The following section examines historical trends of local air pollutants in China and China's progress in addressing them. A study of sulphur dioxide emissions control in the thermal power industry is presented to exemplify how China is approaching environmental concerns in the energy industry.

And though local pollutants are clearly among the most salient today, China's environmental issues growingly include regional[a] and global dimensions. China's dominant energy resource, coal, is also the most carbon intensive. China's primary energy consumption still lags the US, but its annual carbon emissions likely do not and continue to rise. The effects of greenhouses gases on the earth's climate are well accepted globally and in China, and China has been an active participant in efforts to curb greenhouse gases. Looking forward, any concerted global effort to control climate change will require open discourse and cooperation with China.

[a] *For example, pollution particulates may traverse individual economies, or even continents; see Bradsher and Barboza 2006.*

Although the challenges are great, China is in a position to make consequential progress on the environment. In 2006 alone, the capacity of thermal power plants with flue gas desulphurisation (FGD) equipment more than doubled.[b] Key to this accomplishment has been the development of more affordable domestic emissions control technologies along with continued political will. Moreover, as the world's manufacturing base, China and Chinese environmental technologies are set to change the environmental path of other developing economies. Already, domestic engineering and inventiveness are redefining what is possible for China and the world.

[b] *Rosen and Houser 2007*

AIR POLLUTION

China is the second largest energy consumer, but characteristics of its energy sector compound the environment consequences of energy use, particularly its large reliance on coal. Air pollution ranks high among the most important environmental concerns in China today and is an area of high priority for China's leaders and industries.

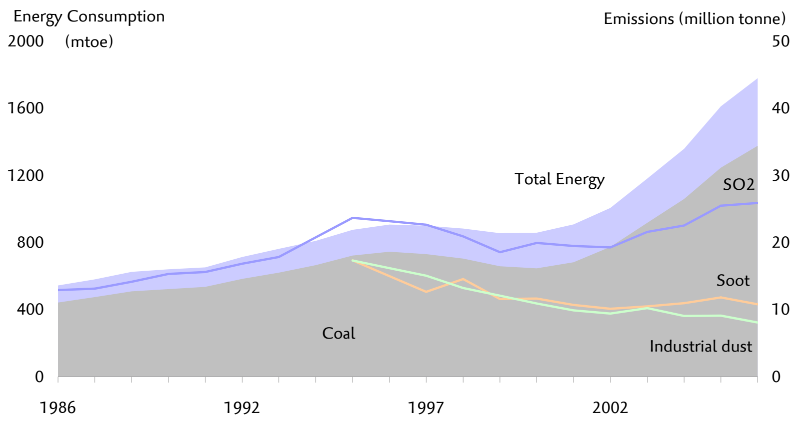
There is a strong correlation between energy use and air pollution. The combustion of coal for electricity and of petroleum fuels for transportation without effective emission control releases a suite of air pollutants including sulphur dioxide (SO2), nitrous oxides (NOx), particulate matter (PM), and heavy metals. China's air pollution burden is particularly great because of coal's dominance in the primary energy mix. In China, coal accounts for about 70 percent and total fossil fuels 94 percent of primary energy. Estimates range widely, but it is clear that coal consumption in China accounts for the majority of SO2 emissions (about 90 percent) and also contributes significantly to NOx (67 percent), PM (70 percent) [c], and heavy metal emissions like mercury (38 percent) [d].

[c] *Fang and Zeng 2007*

[d] *ADB 2008*

Historic Trends

The surge in energy consumption, especially coal consumption, in recent years has led to increased emission of some pollutants, though not all.



130.1 **Energy demand and key emissions (1986-2006)**

APERC 2008, SEPA State of Environment (1995-2008), Wang and Liu 1998

SO2 emissions in China have historically closely tracked energy and coal consumption, but the correlation has weakened since 2000 **[130.1]**. From 2001 to 2006, coal consumption grew at an annualised average rate of 11.8 percent, a 74.7 percent increase over those five years. During the same period SO2 emissions increased as well, though by a smaller margin, about 5.1 percent per year, or 28 percent over the five year period. Other particulate air pollutants were largely decoupled from energy consumption growth. Soot emissions (such as those resulting from coal combustion) stayed relatively constant and industrial dust emissions (such as those from non-energy sources such as cement production) decreased by about 17 percent over the five-year period. This suggests that energy use to emissions ratios are improving, and measures to control dust have been successful in decoupling such emissions from industrial growth. As described above, even trends in SO2 emissions diverged from energy use. Much of this progress was achieved through technological improvements and supported as well by policies measures.

Policy Framework

Aware of the health and economic damages from pollution and environmental degradation, Chinese leaders have emphasised environmental protection, both increasing and broadening their efforts through time. In general, policy makers have taken a stepwise approach, seeking to balance economic progress and environmental protection by implementing the most cost effective measures first. With further economic growth, greater emissions controls and environmental protection will become affordable and necessary.

Early air pollution policies formulated in the 1970s before the onset of the reform period focused heavily on total suspended particles (TSP), especially in northern China. In recent years the main contributors to TSP are emissions from burning coal (soot), cement manufacturing (78 percent of industrial dust), construction sites, and air-blown soils.[e] These emissions tend to be larger particles and removal at point sources is generally cost effective. Industries are subject to stringent soot and industry dust emission standards as well as tax regimes designed to create appropriate incentives for abatement. As seen from **[130.1]**, TSP emissions are holding steady and even decreasing despite strong growth in responsible industries.

SO2 emission regulation started in the 1980s and progressively strengthened through the 1990s. Beginning in 1982, industries paid a modest fee of CNY 40 for every tonne SO2 emitted in excess of standards, but most polluters preferred to pay the fees instead of reducing emissions. Through the 1990s, policies on SO2 expanded and emissions fees increased but enforcement was at odds with local interests. In particular, progress was limited by the high cost of abatement technologies and limited environmental financing. Due to such economic barriers, policies took a more practical and flexible approach. For example, coal-fired power plants were required to install flue gas desulphurisation (FGD) equipment, but not if they burned low sulphur coal. At the same time, other policies limited the extraction of high sulphur coal. This policy helped to reduce the amount of sulphur released per unit coal used, but ultimately had a limited effect on total emissions.

Although SO2 emissions decreased during the *Ninth 5-year plan* period in the late 1990s, they rose steadily during the *Tenth 5-Year plan* period as energy demand increased. China did not achieve its target to reduce major air pollutants, including SO2, to 10 percent below 2000 levels. Instead, SO2 and soot levels rose, missing their targets **[132.1]**. Efficiency improvements and emissions reduction measures taken during the period, though significant, could not fully counteract contemporary rapid growth in fossil fuel consumption. In response, central leaders have since stepped up efforts to control SO2 in the *Eleventh 5-year guideline* period, requiring that more power plants install FGD.

While TSP and SO2 has been heavily emphasised, other pollutants from coal combustion such as mercury and NO2 have not achieved the same attention. Since 2004, all NO2 and other NOx emissions from power plants have been taxed, but at levels generally below the cost of effective abatement. Currently, there are no central targets for limiting NOx emissions from point sources. Coal combustion is also responsible for high levels of mercury emissions. Fortunately, the FGD equipment installed to target SO2 is also effective against mercury, but few policies directly regulate mercury or other heavy metal emission. Such secondary emissions, however, will become increasingly important as TSP and SO2 emissions improve. Already, the share of NO2 contribution to acid rain formation is increasing.[f]

The health consequences of inhaling polluted air and the physical damages from acid rain are well documented. As economic growth in China continues, the physical and health costs of pollution are also rising. In a joint report with the National Bureau of Statistics, the State Environmental Protection Agency (SEPA), now the Ministry of Environmental Protection, estimated the cost of air pollution to be CNY 219.8 billion (real USD 27.31 billion) or 1.31 percent of GDP in 2004 [China Green National Accounting Study Report 2004]. Similarly, a joint study between the World Bank and SEPA estimated that the health impacts of air pollution cost the Chinese economy CNY 157.3 billion (real USD 20.3 billion) or 1.16 of GDP in 2003 [note: This is the report's conservative estimate. For more information, please see the full report "Cost of Pollution in China"]. The study also estimated the annual cost of acid rain including crop damage (CNY 30 billion), material damage (CNY 7 billion), contamination of irrigation water (CNY 7 billion) and fisheries (CNY 4 billion); taken together, acid rain amounted to CNY 48 billion (real USD 6.2 billion) in economic losses.

131.1 **The cost of air pollution**

[e] *World Bank 2001*

[f] *Hao Jiming 2004*

	2000 EMISSIONS	2005 TARGETS	2005 ACTUAL EMISSIONS	TARGET 5-YEAR CHANGE	ACTUAL 5-YEAR CHANGE
SO2	19.951	18.0	25.5	-10%	27.8%
SOOT	11.654	10.5	11.8	-10%	1.5%
INDUSTRIAL DUST	10.92	9.8	8.1	-10%	-16.6%

132.1 **Tenth 5-year target and actual emissions**

SEPA State of the Environment Report (2000-2007)

URBAN AIR POLLUTION

Along with total SO2 and PM emissions, China also monitors ambient air quality of major cities. **[132.2]** describes China's *Ambient air quality standards* established in 1996 and revised in 2000. Most areas are required to meet Class II standards which are, in general, at levels similar to that of US air quality standards, but less stringent than WHO's 2005 guidelines.

POLLUTANT	AVERAGING TIME	CHINA			USA	WHO
		CLASS I	**CLASS II**	CLASS III		
		Nature Reserves, Scenic Areas	**Residential, Commercial, Regular Industry**	Designated Industrial Areas		
SO2 (mg/m^3)	1 year	0.02	**0.06**	0.1	0.078	
	24 hours	0.05	**0.15**	0.25	0.37	0.20
	1 hour	0.15	**0.5**	0.7		
	10 minute					0.5
TSP (mg/m^3)	1 year	0.08	**0.2**	0.3		
	24 hours	0.12	**0.3**	.05		
PM10 (mg/m^3)	1 year	0.04	**0.1**	0.15	0.05	0.02
	24 hours	0.05	**0.15**	0.25	0.15	0.05
NO2 (mg/m^3)	1 year	0.04	**0.08***	0.08	0.10	0.04
	24 hours	0.08	**0.12**	0.12		
	1 hour	0.12	**0.24**	0.24		0.20
CO (mg/m^3)	24 hours	4	**4**	6		
	1 hour	10	**10**	20	40	
O3 (mg/m^3)	8 hours				0.15	0.10
	1 hour	0.16*	**0.2***	0.2	0.24	
LEAD ($\mu g/m^3$)	3 month	1.5			1.5	

132.2 **China's ambient air quality standards (GB 3095-1996 w/ 2000 revisions): a comparison with USA standards and WHO guidelines**

*SEPA website, EPA website, WHO 2006   * Standards revised in 2000*

Since 2000, the air quality of cities has generally improved. While 36.5 percent of cities met Chinese Class II ambient air quality standards in 2000 **[133.1]**, the number grew to 56.5 percent by 2006. Additionally, the number of cities not meeting Class III standards has declined from 33 percent to 8.5 percent.

	1998	1999	2000	2001	2002	2003	2005	2006
NUMBER OF CITIES MONITORED		338	338	341	343	340	522	559
AMBIENT AIR QUALITY								
% MEETING CLASS II		33.1	36.5	33.4	34.1	41.7	51.9	56.5
% MEETING CLASS III		26.3	30.4	33.2	34.7	31.5	37.5	35
% NOT MEETING CLASS III		40.6	33.1	33.4	31.2	26.8	10.6	8.5
AMBIENT SO2								
% MEETING CLASS II (%)	70.8	71.6	79.3	80.6	77.6	74.4	77.4	81.7
% NOT MEETING CLASS II	29.2	28.4	20.7	19.4	22.4	25.6	22.6	18.3
% NOT MEETING CLASS III	15.2		11.7		85	12.1	6.5	4.4
AMBIENT TSP								
% MEETING CLASS II (%)	32.1	40	36.9	35.9	36.8	45.6	59.5	62.8
% NOT MEETING CLASS II	67.9	60	63.1	64.1	63.2	54.4	40.5	37.2
% NOT MEETING CLASS III	37.7		30.3	29.1	29.8	21.2	5.5	5.3

133.1 **Chinese cities meeting air quality standards (1998-2006)**

SEPA State of Environment Report (1995-2007)

	1998	1999	2000	2001	2002	2003	2004	2005	2006
CITIES MONITORED		106	254	274	555	487	527	696	524
% WITH ACID RAIN			61.8	58.8	50.3	54.4	56.5	51.3	54
% WITH SEVERE ACID RAIN (AVERAGE PH LESS THAN 5.6)	52.8	40.6	36.2	36.9	32.6	37.4	41.4	38.4	33.1

133.2 **Acid rain severity in Chinese cities (1998-2006)**

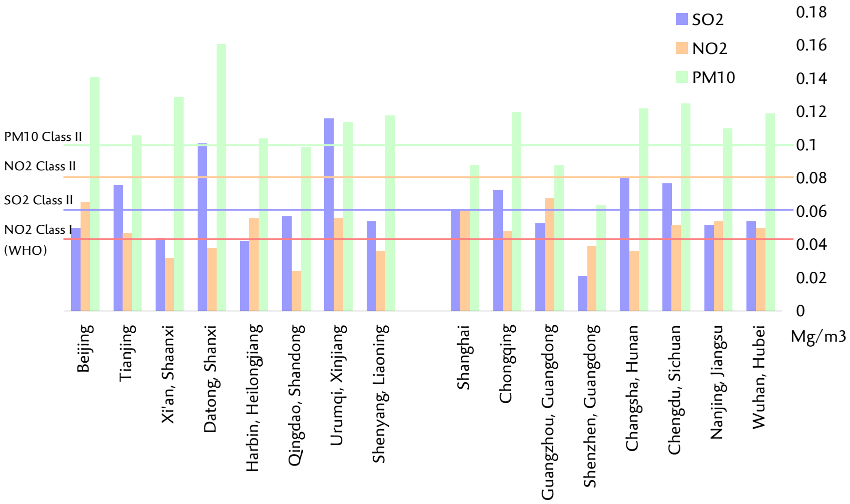
SEPA State of Environment Report (1995-2007)

	1998	2000	2001	2002	2003	2004	2005
SO2 POLLUTION CONTROL ZONE							
CLASS II (%)	32.8	47.7	48.4	40.6	39.1	40.6	45.1
CLASS III	29.7	24.6		31.3	25	29.7	33.9
BELOW CLASS III	37.5	27.7		28.1	35.9	29.7	21
ACID RAIN CONTROL ZONE							
CLASS II (%)	70.6	81.2	79.7	79.5	75	73	73.9
CLASS III	13.7	6.3		13.7	14.7	20	21.6
BELOW CLASS III	15.7	12.5		6.8	10.3	7	4.5

133.3 **Cities meeting air quality standards in the Two Control Zones (1998-2005)**

SEPA State of Environment Report (1995-2007), excluding year 1999

In general, TSP levels improved most from 1998 to 2005, while improvements in SO2 levels and acid rain were only modest. To combat the rising impacts and importance of SO2 pollution, central policy makers created the *Two control zones for sulphur pollution* in 1998. The two control zones target areas where sulphur pollution and its effects are most severe, namely SO2 pollution in northern China and acid rain in southern China. As seen from **[133.3]**, ambient SO2 levels within the control zones, like those in other urban areas, worsened through 2003, before seeing some improvements thereafter.



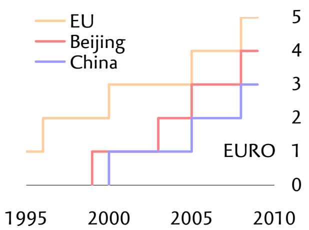
134.1 **Annual ambient air quality in major Chinese cities in the north and south (2005)**

China Environmental Yearbook 2005, APERC 2008

Aside from TSP and SO2, Chinese policies also set standards for inhaleable particulate matter (PM10), NOx, NO2, carbon monoxide (CO), and ozone **[132.2]**. NOx, CO, and ozone are the precursors to photochemical smog and are important emissions from non-stationary sources, namely motor vehicles. NOx pollution and smog are more severe in China's larger cities where motor vehicle ownership is relatively high and rising. Although annual ambient NO2 levels of all cities monitored met Chinese Class II standards in 2006 (below 0.08 milligrams per cubic metre), several cities exceeded WHO recommended NO2 standards (equivalent to Class I). **[134.1]** shows the annual levels of some emissions for key cities in northern and southern China.

Non-stationary Sources and Fuel Quality

Transportation fuels account for a small fraction of energy used in China, but pollution from transport is increasingly important in many large Chinese cities, especially as vehicle ownership rises. In Beijing, vehicle emissions are responsible for 40 percent of PM10, 68 percent of NO2 and 77 percent of CO emissions.[g] To address transportation emissions, China has introduced higher standards for vehicle emissions over time **[134.2]**.



134.2 **Adoption of vehicle and fuel standards (1995-2010)**

Hao Jiming 2004, Tan Dagang 2008, APERC 2008

Although Chinese vehicle emission standards are relatively stringent, the availability of higher quality fuels challenges implementation. If fuel quality falls below engines requirements, emissions will not meet standards. Low quality fuel also increases wear on advanced engines, reducing vehicle lifetimes and increasing maintenance costs.[h]

The quality of motor fuel used in China is generally lower than that in developed economies, and the resulting vehicle exhaust is more polluting. China fuel quality standards, however, have progressed

[g] *Hao Jiming 2004*

significantly over time. Higher standards are often implemented in key cities first before expanding to other areas. For example, leaded gasoline was banned in 8 cities in 1997 before being phased out completely by 2000, and Beijing is leading the way for adoption of higher fuel and emission standards equivalent to those used in the EU, as seen in **[134.2]**. A similar stepwise approach is being taken to reduce sulphur content in gasoline and diesel over time.

[h] *When crude oil prices increased in 2004, some Chinese refineries began processing cheaper, high-sulphur petroleum (without the use of sulphur-ready refining equipment) in order to reduce input costs and meet relatively low, regulated product prices. There is evidence that use of this high sulphur fuel not only contributed to SO2 pollution, but also compromised vehicle engines; Bradsher 2004.*

Despite these efforts, when new auto emission standards (equivalent to EURO III) were set to be in place for all of China starting 2007, the National Development and Reform Commission (NDRC) delayed implementation due to insufficient capacity of oil refineries to produce the necessary low-sulphur gasoline.[i] EURO IV-equivalent standards have being implemented in Beijing and Shanghai since 2008, and refineries are struggling once again to provide the higher quality fuels required.

[i] *Oster and Fairclough 2007*

NDRC's decision to postpone broader implementation of the new standards may have also been influenced by smaller vehicle manufacturers who struggled to meet the higher technological specification.[j] As this case illustrates, coordination between different industries (vehicle manufacturers and fuel producers) is vital to the successful implementation of cleaner technologies. Furthermore, this example emphasises the need for strong domestic technology development when implementing environmental regulations in developing economies. As described below, similar lessons can be drawn from environmental efforts in the power and coal sectors.

[j] *Oster and Fairclough 2007*

SULPHUR DIOXIDE REGULATION IN THERMAL POWER

SO2 is a key pollutant contributing to high TSP levels in China's north and to severe acid rain in the south. Power generation is the largest coal consumer and also the largest contributor to SO2 emissions. Thermal power SO2 emissions in 2005 represented 52 percent of all SO2 emitted in China, totalling 13.28 Mt and an annualised average growth rate of 9.6 percent since 2000.[k] The SO2 situation is changing, however, as flue gas desulphurisation (FGD) technology becomes standard in the power sector.

[k] *Huang Qilin 2007*

Until recently, sulphur removal equipment used in China needed to be imported, and was considered to be prohibitively expensive for adoption at the industry scale. Research and development of domestic Chinese FGD technologies began in the 1970s, and technology transfer to China started in the early 1990s. Localisation of technologies is widely recognised as a crucial element to the success of technology transfer initiatives, but in practice, foreign technology holders had few incentives to share or license their intellectual property Chinese firms at the low prices required. As a result, most technology transfer initiatives focused on funding demonstration projects or capacity building.[l] Without adequate localisation and domestic technology development, the price of FGD remained high. During the *Ninth 5-year plan* period, central plans called for 27 FGD projects, only about one-quarter of the new power plants planned for the period. And, despite ambitious *Tenth 5-year plan* targets to reduce SO2 emissions, the targets for actual FGD

[l] *For more, see Peter Evans (1994) "Japan's Green Aid" and World Bank (2000) "Deployment of FGD Systems in Developing Countries".*

equipment remained low (15 gigawatts of installed capacity and with a further 16 GW in construction). These modest targets reflected the high estimated costs for FGD systems.[m]

Despite years of SO2 emissions regulation and fee collection, the first measure to mandate control was the *Two control regions* policy, established in 1998 to control SO2 pollution and acid rain over 27 provinces/regions. Under the policy, all new and existing power plants using coal with sulphur content above 1 percent were required by law to install FGD equipment. At the same time, coal industry policies also aimed at reducing SO2 emissions by restricted the mining of high sulphur coals. The high cost of FGD equipment, however, meant that switching to low sulphur coal was more economical. As a result, the price for low sulphur coal rose steadily and only 2 percent of installed capacity (5 gigawatts) had sulphur removal in 2000. And though the average sulphur content of consumed coal declined[n], the effect on total emissions was limited.

In July of 2003, all thermal power plants became subject to an emissions levy system for SO2 and NOx discharge. Unlike previous fees, polluters paid charges for total emissions released. Discharge fees for SO2 started at CNY 210 per tonne in 2003 and increased CNY 210 annually to CNY 630 per tonne for 2005 and 2006.[o] Even this new SO2 levy, however, was still considered to be below the cost of abatement. The operating cost alone of FGD devices on a commercial scale were between CNY 400 and 800 per tonne SO2 removed.[p] Shortages of domestic low sulphur coal, however, prompted some generators to install FGD equipment. By 2005, 14 percent (53 gigawatts) of thermal power capacity had installed sulphur removal equipment[q], well exceeding the modest FGD targets of the *Tenth 5-year plan*.

The faster than expected deployment of FGD is partially due to the steady development of more affordable domestic FGD systems. By late 1990s, most FGD equipment was manufactured in China, while some key components were imported. In recent years, however, domestic systems have taken off. Of the FGD systems installed in China, 90 percent are manufactured domestically with Chinese technology. According to the China Electricity Council (CEC), the bidding price for coal power FGD projects in China dropped from CNY 1000 (real USD 130) per kilowatt to CNY 200 (real USD 24) per kilowatt from 2000 to 2006[r], with the more recent bids coming as low as CNY 105 (real USD 14.1) per kilowatt[s]. Limestone (or gypsum) wet FGD methods are most widely used for large units (over 300 megawatts), while smaller units (100-300 megawatts) rely on dry lime FGD. The efficiency of SO2 removal in domestic FGD systems can reach 90-95 percent, though more commonly deployed systems may be less efficient.[t]

During the period 2006-2010, the SO2 policy framework has strengthened even more, requiring much of the power industry to adopt FGD systems as standard. The *Eleventh 5-year guidelines*, once again, target a 10 percent reduction in SO2 over the plan period. To implement these targets, SEPA has partnered with the 6 major power providers in China to assume 75 percent of the reduction targets and reduce total

[m] *Ohshita and Ortolano 2006*

[n] *World Bank 2001*

[o] *Huaneng Power International 2007*

[p] *CICETE 2000; Amounts to real 2005 USD 52 and 104 per tonne SO2. The operation cost for small to medium boilers was even higher, between CNY 700 and 2000 (real USD 91 and 260) per tonne SO2.*

[q] *Huang Qilin 2007; Fang and Zeng 2007*

Although NOx emissions are taxed, the most effective reduction measures are still beyond the financial reach of most power plants. Cost effective technologies like low NOx burners are widely adopted by sub-critical power plants, but these systems cannot meet the Chinese emissions standards for thermal generation. New designs for supercritical systems being implemented can reduce NOx emissions to 300-400 milligrams per cubic metre of flue gas emission. To reach OECD generator emission levels of 200 milligrams per cubic metre, however, generators need more sophisticated systems like selective catalytic reductions (SCR) technology, which require both higher upfront investment and operation costs. Development of SCR, in the same model as FGD, is hoped for the twelfth 5-year period.

136.1 **NOx emissions control and technology development in power**

Huang Qilin 2007

SO_2 emissions from coal-fired power plants by 61 percent to 5 million tonnes. To achieve this, 300 FGD systems are being installed. As with energy intensity targets, precise SO_2 reduction targets vary by province/region, taking into account each region's industrial structure and ability to pay. From 2006, all new coal power plants were required to install FDG equipment while many existing plants are expected to install systems by 2010. Additionally, new economic incentives reinforced efforts to invest in FGD. Power plants running FGD systems were both assigned higher electricity tariffs (an additional CNY 0.015 per kilowatt-hour) to offset operating costs and given grid feed-in priority over other generators— both strong incentives in an industry facing high fuel costs and regulated electricity pricing. As a result, FGD capacity jumped to over 150 gigawatt accounting for 30 percent of total installed capacity by the end of 2006[u].

[r] *ResearchInChina 2007*

[s] *Mcilvaine 2007*

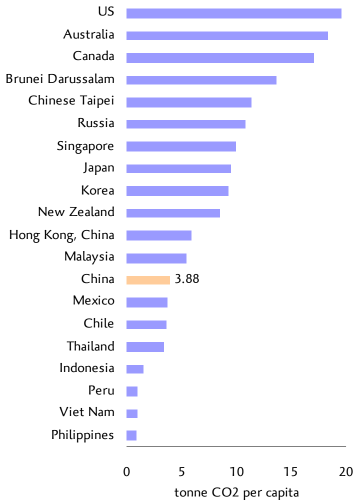
[t] *Rosen and Houser 2007; Huang Qilin 2007*

[u] *Huang Qilin 2007; 104 gigawatts capacity was installed in 2006*

It is likely, then, that China will have little trouble in meeting its *Eleventh 5-year guideline* goal of adding 137 gigawatts capacity of FGD. And while such rapid adoption of FGD reflects the increased efforts of Chinese policymakers, it would not have been possible without domestic FGD technology.

GLOBAL ENVIRONMENT – EYES ON CHINA

Burning fossil fuels is the main source of anthropogenic carbon dioxide (CO_2) and other important greenhouse gases (GHGs) linked to changing the energy balance of the earth. With increased global attention on GHGs and their effects on climate change, many eyes have turned to China, not only because it is set to increase its share in global GHG emissions in the future, but also because it is host to many important new opportunities for change. Since making strides in rapid industrialization and economic progress, China's energy use has boomed. Consequently, China is now among the top emitters of CO_2, though it ranks much lower in terms of cumulative emissions and lower still in carbon emissions per capita **[137.1]**.



137.1 **Per capita CO_2 emissions of APEC economies (2005)**

IEA CO2 Emissions From Fuel Combustion 2005, APERC 2008; excluding PNG

China, as a developing economy, does not have binding carbon reduction targets under the Kyoto Protocol, but China has nevertheless taken action to address climate change based on the principle of "common but differentiated responsibility". The *Eleventh 5-year guideline* target to reduce China's energy intensity by 20 percent from 2005 levels in 2010 is leading the way for more climate friendly development. China's climate strategy focuses on encouraging more efficiency, conservation of resources, and sustainable development. Below is a non-exhaustive list of strategies and example actions currently being taken in China.

STRATEGY	ACTION
INDUSTRIAL RESTRUCTURING TO REDUCE ENERGY INTENSITY	New investment policies are encouraging the development of China's service sector while discouraging energy intensive industries.
INCREASING ENERGY EFFICIENCY OF PRODUCTS	Central policymakers passed higher energy efficiency standards for buildings and motor vehicles and a new labelling programme for appliances. The government will subsidize 150 million high-efficiency lamps over three years.
MORE EFFICIENT UTILISATION OF ENERGY RESOURCES	In the power industry, all new units are expected use more efficient supercritical and ultra-supercritical technology with capacities above 600MW. Central agencies will no longer approve the construction of units below 300MW.
DIVERSIFYING ENERGY AND POWER RESOURCES	China has ambitious longer term goals for the development of natural gas resources, nuclear energy, and hydropower to displace coal.
DEVELOPMENT OF NRE	Targets aim to increase the share of NRE to 10 percent of total energy consumption by 2010 and 20 percent by 2020. Proposed NRE spending will total CNY 1.5 trillion over 15 years. NRE receive priority for grid connectivity, preferential pricing, and special loans and grants.
R&D INTO CLEAN COAL TECHNOLOGIES AND CCS	GreenGen Initiative in China aims to build an IGCC demonstration plant by 2009. In partnership with Australia, China's Thermal Power Research Institute (TPRI) is installing a pilot post-combustion carbon capture project to capture 3000 tonnes CO2 per year.

138.1 **Addressing climate change, strategies and actions**

Actions are exemplary, not comprehensive

A major Chinese wind turbine producer, Goldwind, has rapidly expanded manufacturing capacity to meet China's growing wind energy demands since its founding in 1998. Although once a cost leader in China's domestic wind turbine market, Goldwind now competes with international companies which have since established their own manufacturing bases in China. To stay competitive, Goldwind has re-positioned itself as a technology firm, stepping up engineering capacity to develop home-grown turbine designs of increasing size by opening a design office in Germany while continuing collaborations with Chinese research institutes.

138.2 **Goldwind science and technology company, LTD.**

personal communication 2008

The first three strategies emphasise the need to reduce overall energy demand through more efficient utilisation of energy, while the last three focus on reducing the carbon intensity of China's energy supply. Each strategy also includes a suite of additional direct benefits to energy development and security. For example, recent sustained growth in energy prices and concern for energy supply security has inspired more thinking on efficiency, NRE, and diversification of energy resources. Recognising this, it is clear that under today's constraints, what is good for climate change often reflects what is necessary for robust energy development.

The sheer size of China's current and future energy needs, however, means that China will need to utilise all viable and available energy resources. This means vigorously pursuing coal alternatives on one hand, while extracting and burning more coal on the other. Although natural gas, nuclear, hydro and increasingly wind can make a significant contribution, coal will continue to support the majority of China's energy needs well into the future. Thus, efforts to mitigate climate change will require addressing carbon emissions from coal combustion.

The Role of Technology

In China, controlling carbon emissions from coal combustion will likely follow a path similar to that of SO2 and NOx emissions. Industry wide adoption will require the development of home-grown technologies available at reasonable prices and incentive-based policies to further cut the cost of abatement.

In this context, Chinese efforts to develop low-carbon technologies and CCS are crucial steps in addressing climate change over the long term. Chinese leaders are targeting CCS as a leading-edge technology under the *National medium and long-term science and technology development plan* towards 2020. China is also playing a significant role in the development of low-carbon power technologies, including circulating fluidised bed (CFB), integrated gasification combined cycle (IGCC), and NRE technologies. Domestic mid-sized CFB technologies (210 megawatts and 330 megawatts) are being demonstrated, while about a dozen IGCC projects are in the planning stages. Under the GreenGen Project, a collaboration of eight Chinese enterprises, China aims to build and demonstrate IGCC technology based on domestic engineering. In addition, private Chinese enterprises in recent years have demonstrated international-level technological prowess in NRE.

To realise many of these long-term clean development goals, it is necessary to invest in demonstration projects today. The high cost technology, however, means that the extent of Chinese efforts will depend heavily on securing partnerships and funding from international corporations and organisations. China's willingness to pursue such technologies opens further opportunities for the developed world to participate in China's carbon future and affect climate change. Already, China is the largest recipient of funding under the Clean Development Mechanism (CDM) of the Kyoto Protocol. But as Chinese engineering and manufacturing capabilities progress further, more opportunities will take the form of mutually-beneficial collaborative research partnerships and business ventures.

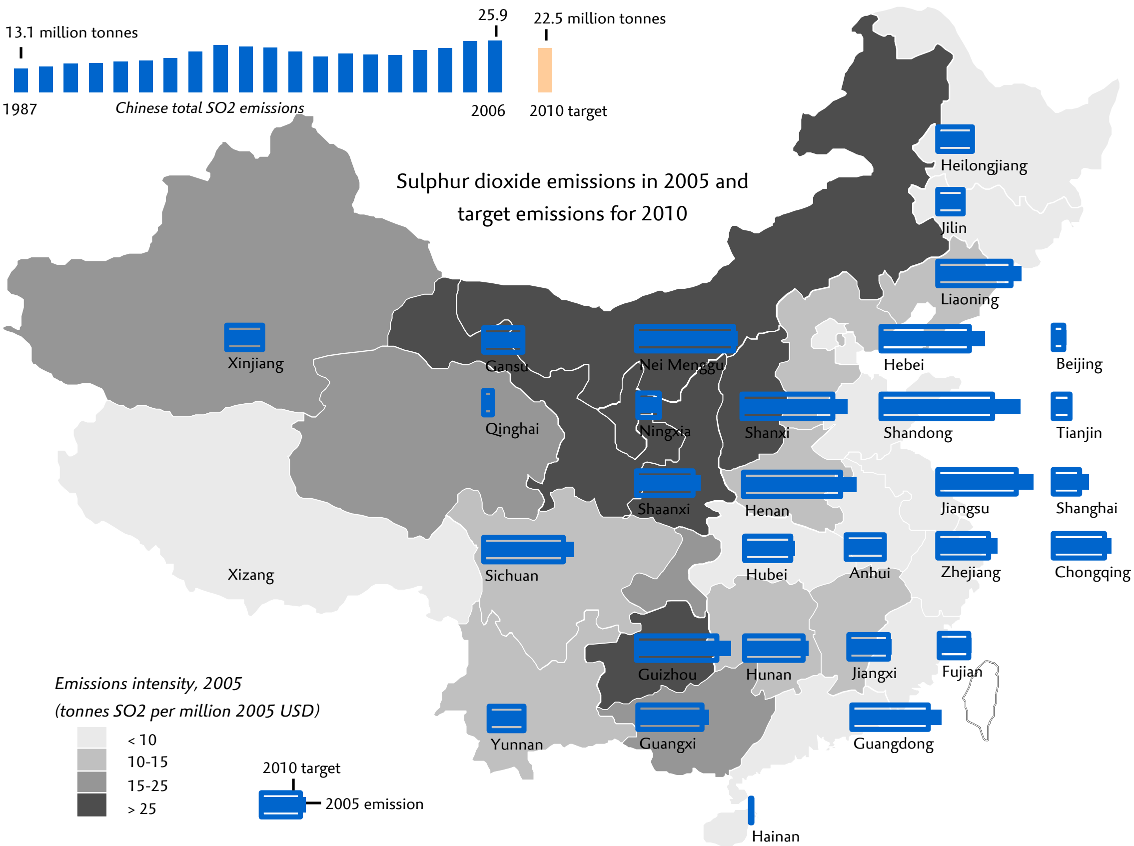
In fact, bilateral and multilateral initiatives have already begun. For example, in 2003, Australia-China Climate Change Partnership helped establish grounds for mutual interests in climate protection between the two economies. Then, under the multilateral Asia Pacific Partnership on Clean Development and Climate (APP) initiative, Australia and China signed an agreement to develop post combustion capture (PCC) systems in Beijing. This is but one of many such cooperations.

And although developed economies play a crucial role in transferring or co-developing technology to help China achieve its climate goals, China must bear the responsibility of disseminating these clean technologies for penetration within the economy as it has with FGD. If this is successful, opportunities abound for Chinese manufactures to promote these technologies internationally and further promote climate protection. Already, more and more customers of Chinese technologies are found abroad, often in other developing economies. For example, Chinese power equipment manufactures have secured contracts in Indonesia, India, Iraq, and other economies. The prospect, then, for sustained development— and international leadership— in clean energy technology deployment is bright.

The rise of Suntech, China's largest solar cell manufacturer, exemplifies China's potential to become a technology leader in clean energy. Since production began in 2001, Suntech has leveraged China's low labour costs to become a price leader, making it a global leader in solar panel manufacturing. Low labour cost (representing 2 percent of Suntech's manufacturing costs compared to an industry average of 5 percent) enables Suntech to manually assemble finished solar panels, reducing damage rates to valuable silicone wafers compared to automated processes used elsewhere. This novel approach has helped reduce the cost of PV energy for consumers worldwide. Furthermore, Suntech benefits from China's low equipment cost and skilled researcher wages to help realise its R&D ambitions of cutting production costs even further and becoming a technology leader in the industry.

139.1 **Suntech Power**

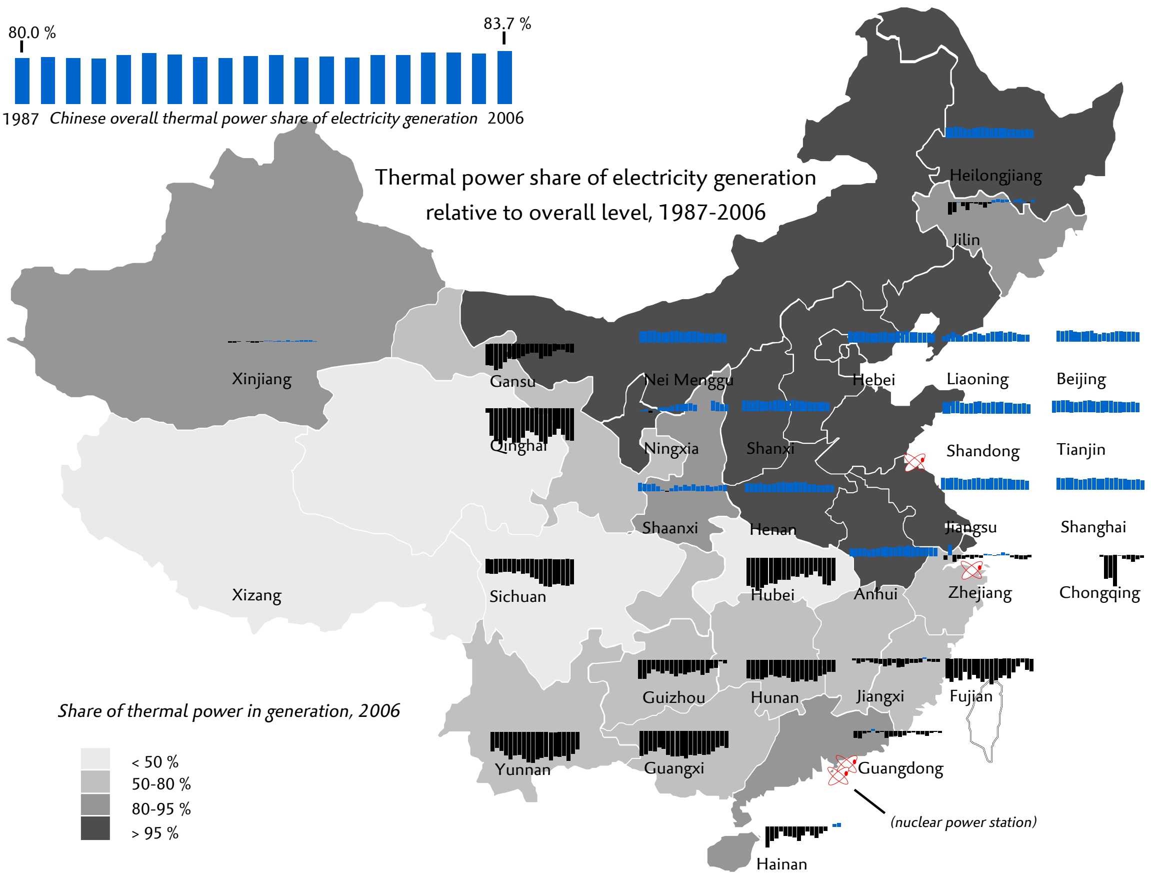
Jonathan Watts 25 July 2008, China Daily 23 April 2007



140.1 **SO2 emissions**

APERC 2008

- Total emission of sulphur dioxide in China rose from 13.1 million tonnes in 1987 to 25.9 million tonnes in 2006. Emissions initially peaked at 23.7 million tonnes in 1995 but began to grow again in 2003 and this previous level was exceeded in 2005.
- Regionally, there is broad variation in total emission levels. Shandong had the most total emissions in 2005, 2.0 million tonnes, and surrounding provinces were among the highest as well. Emission reduction targets for 2010 assigned to each province focus on total emission reductions rather than an intensity indicator. The economy average share of reduction is set at about 11.9 percent over five years, or about 2.5 percent annually, but varies among individual provinces from highs of 25.9 percent reduction in Shanghai, 20.4 percent in Beijing, and 20.0 percent in Shandong, to a low of zero percent reduction in Gansu, Qinghai, Xinjiang, Xizang, and Hainan.
- Economic intensity of sulphur dioxide emissions is highest in Nei Menggu, Ningxia, Gansu, Shaanxi, Shanxi, and Guizhou, where it exceeds 25 tonnes per million USD.



141.1 **Power generation mix**

APERC 2008

- Overall, the share of total electricity generation provided by thermal power rose slightly from 20.0 percent in 1987 to 83.7 percent in 2006, with some fluctuation.
- Regionally, there is a clear divide between the relatively hydrologically-rich southeastern, southern, and western provinces that have generated a smaller share of electricity from thermal power sources, and the coal- or oil-rich north-central and northeastern provinces where thermal power took a larger share. Such trends within each province were generally stable over time.
- There are currently four nuclear power stations (with multiple units at each site) operating along the eastern coast.
- The share of thermal power in generation has wide variation among provinces, exceeding 95 percent of generation in the north and east but less than 50 percent in provinces such as Sichuan or Hubei.

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